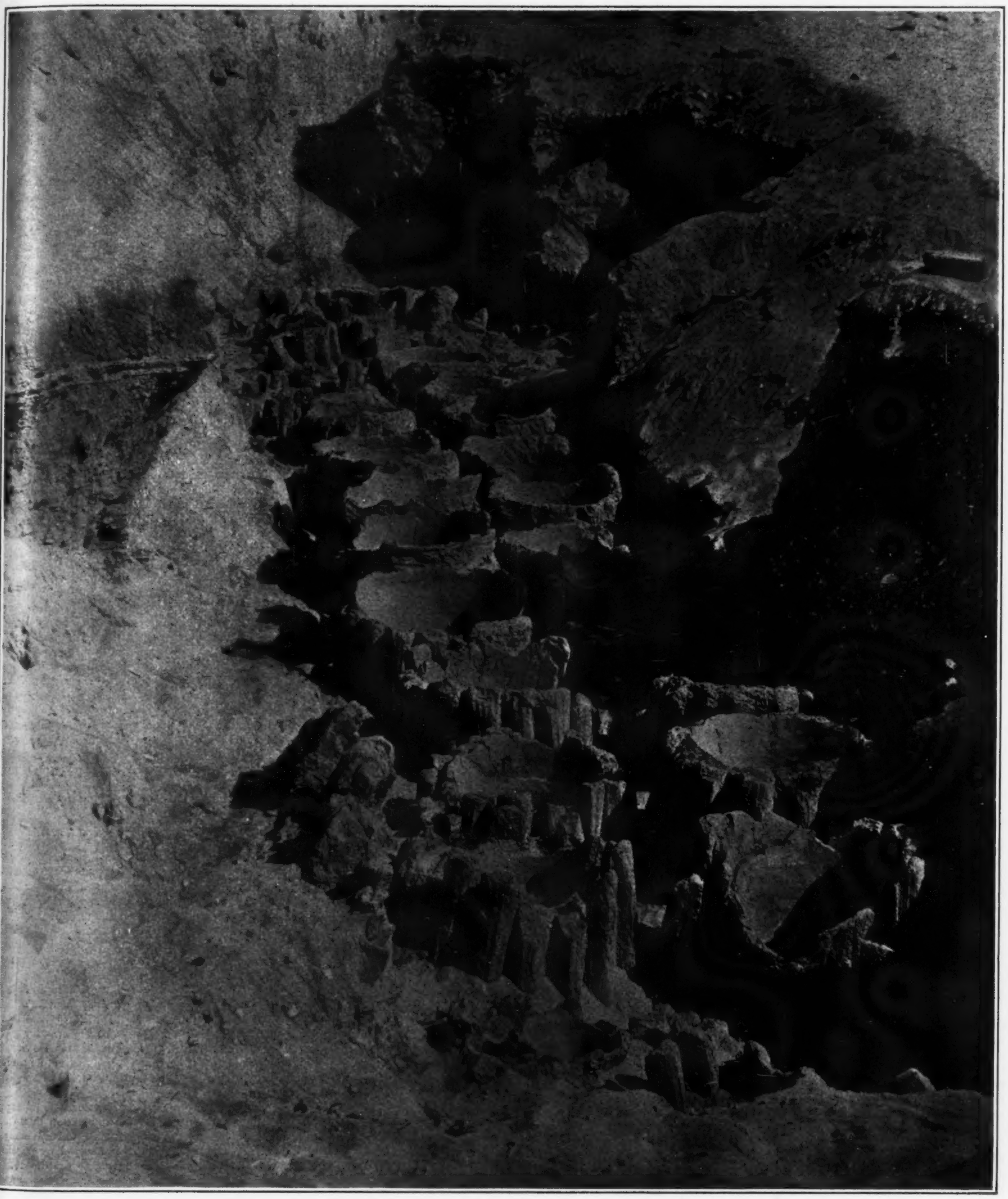
Monita

SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXVI
NUMBER 1963

NEW YORK, AUGUST 16, 1913

10 CENTS A COPY
$5.00 A YEAR



A row of kilns which must have been used for roasting grain.

PREDYNASTIC FURNACES IN EGYPT. A PROBLEM IN ARCHAEOLOGY SOLVED.—[See page 101.]

The New International Carat of Two Hundred Milligrammes—II*

A Movement for Uniformity in Jewelers' Weights

By George Frederick Kunz, Ph.D., D.Sc.†

Concluded from Scientific American Supplement, No. 1962, Page 83, August 9, 1913

We give here a simple and correct rule for calculating the weight and price of diamonds under the new and the old standards. As a preliminary operation the number of sixty-fourths is to be expressed as a decimal fraction in the usual way, by dividing the numerator by the denominator 64; for example, 1/4, 1/8, 1/32, 1/64=27/64; 27÷64=0.422.

The old international carat=205 milligrammes.

The new international carat=200 milligrammes.

Consequently:

The old carat is 2.5 per cent heavier than the new carat, and the new carat 2.44 per cent lighter than the old carat.

The old carat weighing 2.5 per cent more than the new carat, 2.5 per cent should be added to price of new carat to obtain price of old carat.

The new carat weighing 2.44 per cent less than the old carat, 2.44 per cent should be deducted from price of old carat to obtain price of new carat.

The old grain being one quarter of old carat and the new international grain one quarter of new carat, the same rules apply to grains.

To convert old carat-weights into new carat-weights, add 2.5 per cent to weight of old carat; deduct 2.44 per cent from price of old carat.

To convert new carats into old carats, deduct 2.44 per cent from weight of new carat; add 2.5 per cent to price of new carat.

Examples:

How many new international carats and what would be the price per carat of 97, 1/4, 1/8, 1/32, 1/64 old carats at $100?

In decimals	97.422	
Add 2.5 per cent	2.435	
New carats	99.857	
Price per old carat		$100.00
Deduct 2.44 per cent		2.44
Price per new carat		$97.56

which for 99.857 carats would give $9,742.05.

How many old carats and what would be the price per carat of 99.857 new carats at $97.56?

New carats	99.857	
Deduct 2.44 per cent	2.436	
Old carats	97.421	
Price of new carat		$97.56
Add 2.5 per cent to price of new carat		2.44
Price of old carat		$100.00

97.421 carats at $100 per carat=$9,742.10.

A useful publication in French to aid in making these computations is that issued in 1912 by G. Ymonnet, and entitled *Bareme des relations entre le carat metrique a 200 mm. et le carat ancien a 205 mm.* The exact ratio of the English Board of Trade carat, that officially recognized in Great Britain, to the new international carat, is as 1 to 1.0265.

The fact that the general adoption of the new international carat owes so much to the activities of the Director of the International Committee of Weights and Measures, the directing body of the International Bureau of Weights and Measures, suggests a few words in regard to this committee. Organized under a treaty signed in Paris, in 1875, by 20 of the leading nations of the world, it was intrusted with the important task of supplying the various interested nations with standard platinum-iridium meters and kilogrammes, conforming strictly to their prototypes, the original meter and kilogramme recognized as standards by the French government in 1799. When, in 1889, this task had been successfully accomplished, one of the new meters and one of the kilogrammes were chosen as international prototypes, and each of the different countries represented in the Bureau received an allotment of one or more of these standards of length and mass. Two meters and two kilogrammes fell to the lot of the United States. These are now kept at the Bureau of Standards at Washington and constitute the fundamental metric standards of length and mass for our land. The international prototypes in Paris are carefully preserved in a specially constructed underground vault, and are only accessible to the International Committee. To insure the maintenance of strict conformity between the different metric standards, the committee contemplates the introduction of comparisons between them at such times as may seem expedient. The International Bureau has the joint support of the following countries: the United States, Great Britain, Germany, Russia, France, Austria-Hungary, Belgium, Argentine Confederation, Spain, Italy, Mexico, Peru, Portugal, Roumania, Sweden, Norway, Switzerland, Venezuela, Japan, and Denmark.[14]

There is, in the rooms of the Chambre Syndicale in Paris, a standard balance, which is verified once every month by the Maison Exupère. Access can be had to this balance by any member at any time, and this aids materially in securing standard weights of absolute accuracy. There are two great sources of error: one is the accretion of dust and perspiration; the other is the wearing away of the weights by friction on the pan of the balance, in the weight box, and by the tweezers, in lifting them up.

The writer had a set of the new international weights made in 1910. These new weights, which will be required as soon as the new international carat of 200 milligrammes shall be generally recognized and employed by American gem-dealers as the standard weight for precious stones, have already been made by a number of balance-makers. The price charged for a set of these weights, 18 in number, ranging from 100 carats to 1/100 carat, is $3.80; of course, a fuller set would cost a proportionately higher price. It has been stated that there is really no such weight as a "pearl grain;" yet while this is, strictly speaking, a fact, the so-called "pearl grain" being merely a quarter-carat, the term has so generally been used and is so well understood by all familiar with precious stones and pearls, that it may be said to be "consecrated by usage." In any case, however, the statement that, with the introduction of the new carat, pearls can be weighed with greater accuracy, is a perfectly just one, for the advantage of having a fractional weight as small as 1/25 of a "pearl grain," instead of being confined as at present to the larger fraction of 1/16 (1/64 carat), is clearly manifest.

The astute diplomatist, Talleyrand, is credited with the basic idea of the metric system, namely, the acceptance of the length of a pendulum beating seconds on latitude 45 degrees, as a standard unit of length. This proposition, made by him in 1790, was accepted by the French National Assembly and the sovereign, Louis XVI. The details of the system were worked out by the great French mathematicians Borda, Lagrange, Laplace, Condorcet, and Monge, who constituted a committee appointed by the French Academy of Sciences for this purpose.

Decimal notation, without which the metric system would have been an impossibility, is said to be of Hindu origin, although it reached Europe through the Arabs. Abu Ja'far Mohammed ben Musa, named Al-Khowârazmî from his birthplace, Khwârazm (Khiva), and who flourished in the ninth century A. D., is considered to be the originator or introducer of decimal notation among the Arabs, and the introduction of the system into Europe has been traced to a translation of one of his works made in 1202 by Leonardo of Pisa.

The nine numerals with the zero were introduced among the Arabs about 773 A. D. and are by some believed to have been brought by an Indian ambassador to Bagdad at that time. Of their use in India at an earlier period we have monumental evidence in rock inscriptions, and, while the earliest date expressed in these Hindu numerals is 738 A. D., there is sufficient proof of their employment as early as the sixth century.

Introduced to Europeans at the beginning of the thirteenth century, the so-called Arabic numerals very gradually came into general use. For example, in the calculation of the tides in London, in the thirteenth century. A work of Petrarch, printed in Cologne in 1471, has the pages numbered in this way.

The earliest example of the decimal point is said to be found in the arithmetic of Frances Pellos, written in the dialect of Nice, and published at Turin in 1492[15].

The first appearance of the symbols + and — in a printed book is in an arithmetic of Johann Widmann printed in Leipzig in 1489,[16] and the sign denoting equality, =, is first found in print in Robert Recorde's (1510?-1558) *The Whetstone of Witte, or the second part of Arithmetike*, London, 1557. He is believed to have adapted it from a similar sign used in medieval manuscripts as an abbreviation of the Latin *est*, "is."[17] Rahn is credited with the first use of the symbol of division, ÷, and Thomas Harriot is said to have been the first to print the signs > and <, denoting respectively excess and deficit, in his *Artis analyticae praxis*, London, 1631.

A simple method of making a rough mental calculation of certain metric weights and measures into equivalents of the English standards is given by Albert A. Cary.[18] This may be in many cases accomplished by merely adding 10 per cent to the figures expressing the metric quantity. For instance, 1 meter equals 1.094 yard nearly; the error in turning meters into yards in this way amounts to a trifle less than 6/1,000 yard in each meter. Thus 67 meters would equal 67+6.7 yards, or 73.7 yards, or, multiplying this by 3, 221.1 feet; the more exact equivalent being 73.27 and 219.82, respectively. With the kilogramme the metric figures must be doubled and then 10 per cent added to the product to get an equivalent number of avoirdupois pounds, as the kilogramme equals 2.204 pounds avoirdupois. Hence 76 kilogrammes can be thus roughly turned into pounds: 76×2=152+15.2=167.2 pounds, the exact equivalent being 167.504 pounds, a comparatively slight error when only an approximation is sought. An addition of 5 per cent to the figures expressing a given number of liters would also offer a fairly close approximation to the number of quarts. If we take, for example, 64 liters, we have: 64+3.2=67.2; here the exact equivalent is 67.629 quarts.

In a communication to the Société Française de Physique in Paris, Edouard Guillaume calls attention to a slight difference which exists between the liter and the kilogramme or cubic decimeter of water. Accurate modern measurements have shown that the difference amounts to 27/1,000,000 or a little over 1/40,000.

The metric system was legalized in the United States by the act of July 28th, 1866, and although its progress toward popular and general recognition and employment has been unfortunately slow, at intervals since that date certain special official enactments have prescribed its use in particular cases, as in the postal service, where the post offices exchanging mails with foreign countries are provided with balances denominated in metric grammes, under the terms of Section 3,880 of the Revised Statutes. A much more important case, however, because it concerns an exclusively national use of the metric system, was the enactment that the weight of the half-dollar, the quarter-dollar, and the dime should be computed in grammes, the half-dollar to weigh 12.5 grammes and the quarter-dollar and dime respectively one half and one fifth of this weight. In 1894 a further step was taken by the enactment that the international units based on the metric system should be "the legal units of electrical measure in the United States."

Already, by an order approved April 15th, 1878, the Secretary of the Navy had directed that the metric system should be used in the Medical Department of the Navy, and later, April 13th, 1894, it was ordained that all requisitions and accounting for medical supplies in the War Department should be made in conformity with the metric standard. The scope of these regulations was broadened by Executive orders of November 21st, 1902, providing that "for all official, medical, and pharmacal purposes, officers shall make use of the metric system of weights and measures."

In our colonies, Porto Rico and the Philippines, the metric system had been in use long before the date of our occupation, and its continued use, for Porto Rico, was made obligatory by a proclamation of the military governor, dated March 18th, 1899, while in the case of the Philippine Islands the continuance of its employment was legalized under Sections 3,569 and 3,570 of the Revised Statutes.

It is not only in the form of the new international carat that the metric system has found application in determining the dimensions of precious stones. Certain classes of these stones are distinguished and sorted by passing them through sieves graded according to the diameters of their apertures expressed in millimeters. The appara-

* Paper read before the American Institute of Mining Engineers.

[14] *The International Metric System of Weights and Measures*, pp. 3, 4, Department of Commerce and Labor, Bureau of Standards, S. W. Stratton, Director (Washington, 1906).

[15] *Sen segue de la art de arithmeticha, et semblatment de ieumetrica dich ho nommaius copendio de lo abaco (compilada es ca opera per Fr. Pellos), Impresso in Thaurino lo presente copendio de abaco per meistro Nicolo benedeti he meistro Jacobino lugio de sancto germando-Nei anno* 1492 *ad Di* 28 *de Septembrio.*

[16] Widmann, J., *Behede und hubsche Rechenung allen Kauffmanschafft*, Leipzick, Chr. Kacheloffen, 1489. 8 deg., 236 pp.

[17] The title "Whetsone of Witte" is the translation of *cos ingenii*, a punning allusion to *cosa* (thing), early used to signify our algebraic *x*, or unknown quantity.

[18] Simple Approximate Metric Conversions, Power, vol. xxxvii, No. 7, pp. 217 to 219 (February 18th, 1913).

tus used consists of a brass ring grooved on the inner side so that there may be set within it a series of sieves. A sieve of a certain grade having been duly adjusted, the stones to be measured are placed upon it, and shaken to and fro until all smaller than the apertures of this particular sieve have passed through it. These stones are then gathered up and placed upon a sieve with smaller apertures, and those which do not pass through this latter sieve are classed by its serial number. Pearls are also sometimes classified in the same way.

Here, however, as in the case of the carat, a fixed standard has been lacking, there being Paris stone-sieves with a difference of about 1/5 millimeter, Paris and Idar "pearl-sieves" with a progressive difference amounting to from 1/25 to 1/5 millimeter, and Bohemian garnet-sieves with approximately the same progressive difference as the Paris sieves. But this theoretical uniformity does not exist practically, for the sieves are not standardized, and those used by one dealer may and do usually differ from those used by another. Moreover, the ratio of difference between sieve and sieve is not constant. In the case of some numbers, or grades, it amounts to 1/3 millimeter, while in the case of others it is but 1/10 millimeter, so that a great quantity of stones will be placed in certain grades and very few in certain other grades. To obviate all these difficulties an international series of sieves has been proposed. The No. 1 sieve is to have apertures of 1/10 millimeter, each succeeding number to have apertures 1/10 millimeter greater in diameter, so that in the case of the No. 10 sieve this would measure 1 millimeter; No. 20, 2 millimeters, and so on. By this means the number of the sieve would immediately and invariably denote the diameter of the holes; in the case of No. 17, for instance, the diameter would be 1 7/10 millimeters; for No. 36, 3 6/10 millimeters. As another improvement, it is suggested that the sieves be made as thin as possible, and that thin steel plates be substituted for brass as a material.

COUNTRIES WHICH HAVE DEFINITELY ACCEPTED AND LEGALIZED THE METRIC CARAT.

Spain	1908
Japan	1909
Switzerland	1909
Italy	1910
Bulgaria	1910
Denmark	1910
Norway	1910
Holland, law promulgated April 7th	1911
Portugal	1911
Roumania	1911
Sweden	1911
France, adopted June 22nd, 1909; legalized Jan. 1st	1912
Germany	1912
Belgium	——

The following resolution was adopted at the Eighth Annual Conference on the Weights and Measures of the United States, held at the Bureau of Standards, May 14th to 17th, 1913:

"*Resolved*, that this Conference is in favor of the metric carat weight of two hundred (200) milligrammes being adopted as the standard of weight for precious stones."

It has been suggested that as every State having a special department of weights and measures should be properly equipped for the task of testing the accuracy of weights and balances used for precious stones, provision should be made for officially verifying such weights and balances, the owners merely needing to defray the costs of transportation, which would be inconsiderable.[19]

In a letter sent in the latter part of May, 1913, to G. E. M. Johnson, Secretary of the Decimal Association of London, some important information is conveyed by P. A. MacMahon, deputy warden of the standards of the English Board of Trade, promising the general adoption of the new metric carat in England in the near future. He writes:[20]

"In reply to your letter of the 21st of May respecting the adoption of the metric carat in the sale of diamonds and other precious stones, I have to acquaint you that the Department has now decided to take steps to make the metric carat and its necessary multiples and submultiples standard weights in the United Kingdom, and that an Order in Council giving effect to this decision will probably be issued this year."

On July 1st, 1913, the provision goes into effect in Belgium making the metric carat the standard of weight for precious stones in that country, and it is confidently expected that in Holland, where the extensive diamond interests are so nearly allied to those of Belgium, a similar provision will be very shortly enacted. It is thus probable that by 1914 the six countries chiefly interested in the diamond trade, the United States, Great Britain, Germany, France, Holland, and Belgium, will all be freed from the use of the antiquated and complicated carat-weights of the past.

The value of pearls is computed by squaring the number of "pearl-grains" (quarter-carats) and multiplying the product by a figure determined upon as the base value of the grain. To ascertain the exact value of a pearl having a certain weight in metric carats, we should first multiply the figures by four, which will give us the number of "metric pearl-grains," and then multiply this product by itself, the result being in turn multiplied by the figure representing the value in dollars of a "base-grain." For example, in the case of a pearl weighing 3.64 metric carats and having a base-grain value of $6, we proceed as follows:

$3.64 \times 4 = 14.56$ (number of "pearl-grains").

$14.56 \times 14.56 = 211.9936$.

$211.9936 \times 6 = 1271.9616$ (value of pearl in dollars).

That is to say, such a pearl would be worth $1,271.96. Several books have been published containing the squares and cubes, and square-roots and cube-roots, of a long series of numbers, and any one of them would prove useful in these operations.[21]

In an interesting and instructive address delivered by Dr. Louis A. Fischer, of the United States Bureau of Standards, before the Retail Jewelers' Association of the District of Columbia, the speaker took occasion to assure his hearers that the jewelers of this country could count upon the assistance and support of the Bureau of Standards if they followed the example set by their European confrères.[22]

For jewelers and gem-dealers doing business in New York, a fact of considerable interest is that the Mayor's Bureau of Weights and Measures has, since July 1st, 1913, placed its services at the disposal of the general public in correctly determining the weights of precious stones according to the carat of 200 milligrammes. Commissioner John L. Walsh states that the mechanical department of the Bureau, at 224 West 49th Street, is now supplied with facilities for weighing gems from 1/100 carat to 500 carats, in accordance with the new standard. While no other city department is as yet able to furnish this service, the New York State Bureau of Weights and Measures, at Albany, and the National Bureau of Standards, at Washington, D. C., can verify sets of the new weights by means of the standard weights deposited there.

In conclusion, it is a pleasure to chronicle the definite official acceptance of the new carat by the United States Treasury Department. On June 17th instructions were issued by the Department to collectors of customs prescribing the metric carat of 200 milligrammes as the standard unit of weight for imported diamonds and other precious stones, and for pearls; these instructions to take effect July 1st, 1913.

The use of the new carat weights has received the approval of the National Jewelers' Board of Trade, A. Henius, president; the National Jobbers' Association, and the American National Jewelers' Association; and each of these bodies has passed a resolution commending the metric carat and recommending that members should employ it as a standard weight after July 1st, 1913.

The resolutions of the National Jewelers' Board of Trade, passed at a meeting of the Board of Directors, held November 14th, 1912, read as follows:

After discussion it was moved, seconded, and carried: "That the National Jewelers' Board of Trade most heartily indorse the movement of the committee that was formed for the purpose of the adoption of the decimal metric carat, and recommend to its full membership the adoption thereof, in accordance with the Resolution passed at the meeting held October 29th, and that the president be authorized to appoint ten members of this Board to co-operate with the committee to be appointed by Mr. Rothschild, and that the secretary be instructed to notify every member of the Board of the action taken here to-day; that the president or the secretary communicate the action of the Board to the proper officials of the National Retail Jewelers' Association and National Jobbers' Association, requesting them also to use their influence for the decimal metric carat system."

The following letters and telegrams register the final success of the international metric carat in our country:

(*Copy.*)

DEPARTMENT OF COMMERCE AND LABOR,
BUREAU OF STANDARDS.
Washington, June 13th, 1913.

Dr. George F. Kunz,
405 Fifth Avenue, New York City.

MY DEAR DR. KUNZ:

I beg to acknowledge receipt of your letter of June 12th, regarding the adoption of the metric carat. In reply, I would state that the order the Treasury Department intends to issue regarding the metric carat was submitted to the Department of Commerce for comment and criticism and has been passed upon by this Bureau. It is our understanding that the Treasury Department will issue this order to take effect on and after July 1st, 1913.

With kindest regards, I remain,
Sincerely yours,
(Signed) S. W. STRATTON, Director.

(*Copy of Telegram.*)

WASHINGTON, D. C., June 18th, 1913.

Dr. George F. Kunz,
405 Fifth Avenue, New York.

Notice of the Treasury Department concerning adoption of Metric Tariff will be promulgated July 1st, according to word received from Treasury Department to-day. You are therefore at liberty to publish Bureau letter.

S. W. STRATTON.

(*Copy.*)

TREASURY DEPARTMENT,
Washington, June 16th, 1913.

Mr. George F. Kunz,
405 Fifth Avenue, New York.

DEAR SIR:

Replying to your letter of June 12th, asking if the Treasury Department will adopt or reject the new international carat of 200 metric milligrammes, on July 1st, I am very glad to inform you that the Department has adopted the new international carat, beginning July 1st, and collectors of customs have been so informed.

Respectfully,
JAMES F. CURTIS, Assistant Secretary.

(*Copy.*)

French Telegraph Cable.
PARIS, June 20th, 1913.

George F. Kunz,
409 Fifth Avenue, New York.

Merci telegram communiqué à confrères accueillez félicitations cordiales pour consécration à laquelle avez donné tout votre devouement. LEON RHEIMS.

In addition to the jewelers already noted, no one has been more indefatigable in the introduction of the international metric carat of 200 milligrammes than Mons. Ch. Ed. Guillaume, Director of the Bureau Internationale des Poids et Mesures of Sèvres; Mons. Leon Rheims, President Chambre Syndicale de Negociants de Pierres Précieuses of Paris; and in this country, Dr. S. W. Stratton, Director of the Bureau of Standards, Department of Commerce and Labor, and Hon. James F. Curtis, Assistant Secretary of the United States Treasury.

Our Phosphate Production

PHOSPHATE rock, which is the principal source of one of the three fertilizing elements necessary for plant growth, was marketed in the United States last year to the extent of 2,973,332 long tons, valued at $11,675,774. This was a slight decrease in both quantity and value compared with the figures for the preceding year, but the amount of phosphate rock mined was greater than in 1911, excepting in South Carolina. In Florida the increase was 3 per cent, in Tennessee it was over 12 per cent, and in the western phosphate field it was over 10 per cent.

Stocks of phosphate rock on hand also increased in the two main producing Southern States, Florida and Tennessee. On the whole the industry in the main southern phosphate field was active.

The production of phosphate rock in Florida was 81 per cent of the entire output of the United States. The output of this State, which at the present time leads in the phosphate industry, was with one exception, that of 1911, the greatest in the history of the State. The quantity marketed for the year was 2,406,899 long tons, valued at $9,461,297, a slight decline both in tonnage and value compared with 1911. Tennessee furnished 14.2 per cent of the phosphate marketed in the United States in 1912, the total production of the State being 423,331 long tons, valued at $1,640,476. In South Carolina 131,490 long tons was marketed, valued at $524,760, a considerable decline compared with 1911.

In the Western States the production of phosphate came from Idaho, Utah, and Wyoming and amounted to 11,612 long tons, a gain of 10.5 per cent compared with 1911. The value of the product increased considerably, the average price per ton being greater in 1912 than in 1911.

The United States Geological Survey has just published an advance chapter from *Mineral Resources*, 1912, by W. C. Phalen, giving, besides statistics of production of phosphate rock for the whole country, figures showing the production of the individual States for the last five years. Tables showing imports and exports of fertilizer materials are also given, as well as the production of phosphate rock in the principal countries of the world. The phosphate industry in the different States is briefly discussed, and the author gives general information of interest to those engaged in the phosphate trade.

[19] G. A. Dazney, The Application of the Weights and Measures Question to the Jewelry Trade *Jewelers' Circular Weekly* (April 24th, 1912).

[20] *Jewelers' Circular Weekly* (June 11th, 1913).

[21] *Barlow's Tables of Squares, Cubes, Square-Roots, Cube-Roots, Reciprocals of all integral numbers up to 10,000* (London, 1882).

Dr. A. L. Crelle's *Rechentafeln* (Berlin, 1889).

W. Palin Elderton, *Tables of Powers of Natural Numbers; in Biometrika*, vol. ii., and iv., pp. 474-480 (Cambridge, November, 1903).

[22] In a personal letter, March, 1913.

Fig. 1.—A typical Japanese Pagoda. It is a remarkable fact that these pagodas, built hundreds of years ago, embody the principle of the modern seismograph.

Earthquakes in Japan*

Notes from a Country in Which Earthquakes are Almost an Everyday Occurrence

By Blackford Lawson, Member of the Japan Society

Fig. 2.—A Japanese bell-tower, wherein the suspended bell acts as a safeguard against earthquakes, securing stability combined with flexibility and resistance to distorting stresses.

No other country in the world probably affords such facilities for the study of earthquakes as Japan, nor is there anywhere else such necessity for their scientific investigation.

Nearly one thousand four hundred of these phenomena are recorded annually in the whole of the Empire, and in Tokyo alone there are, on an average, fifty earthquakes that can be felt during the year, or about one a week. Earthquakes, as every one knows, occur in all regions adjacent to active volcanoes, as in the neighborhood of Teneriffe, Vesuvius, Etna, and Stromboli, which are simply the safety-valves of a single earthquake district. So also Japan, Sumatra, Java, and the islands of the East Indian Archipelago are liable to fearful earthquakes; and geologists say that much of Japan would never have existed but for the seismic and volcanic agency which has elevated whole tracts above the ocean by means of repeated eruptions.

It is, therefore, only to be expected that it occupies a unique position in the world as regards seismology. Consequently, there is a special chair of seismology and an institute attached to it in the University of Tokyo, and also a special committee for the investigation of earthquakes, under the direct control of the Minister of Education. Besides this, all the provincial meteorological stations throughout Japan are equipped with instruments for recording and measuring earthquakes, and seismic phenomena are systematically studied.

In the interior, the writer frequently met, in an out-of-the-way cave or on the mountain-side, members of the Seismological Society of Japan, originally organized by Prof. Milne, who, with their delicate instruments set up, were mapping down every quiver of the earth's crust.

A study of a map of the world will show that the configuration of earthquake centers, as seen in India, Japan, Java and Sumatra, is that of an arc, and that in each case the earthquake region lies on the outer or convex side of the arc, where the deformation of the earth's crust seen in the curvilinear form of the arc shows that the strain is greatest. Thus in the Himalayas, severe earthquakes take place on the outer or steep side, rather than on the concave or Tibetan side; and in the case of the Japan arc, great seismic disturbances occur almost always on the outer or Pacific side, where the Pacific Ocean forms the greatest area of depression in the world, and only small local shocks originate on the inner or Japan Sea side of the arc.

After the great catastrophe in Northwest India on April 4th, 1905, the Japanese Government, ever eager to study earthquake phenomena at first hand, sent their leading seismic expert, Dr. F. Omori, Professor of Seismology at the Imperial University, Tokyo (see Fig. 3) to investigate and report on the nature of the disaster. During several months' stay in Tokyo, the writer was honored by the friendship of this eminent man, and spent many delightful hours in his lecture-rooms at the University, and also with his charming family in their picturesque home. From Prof. Omori, she learned that the appalling loss of life in Dharmsala and the Kangra Valley was due to faulty construction, the houses being built of stones roughly piled together without any good cementing material, and surmounted by a heavy roof.

In construction the first point is to make the foundation solid and as large as possible, because, if weak, cracks will be produced. In two-storied buildings, the upper story suffers more than the lower ones, the vibration being greater at a height than at the base. Again, a structure may be very heavy, but if built of bad material it can have no resisting power, and it will simply "smash down," for good material and good construction are more

* Reproduced from *Knowledge*.

Fig. 3.—Prof. Omori with vibrating recorder at the Seismological Institute, Tokyo. By means of this instrument vibrations of railway bridges and steamers are measured.

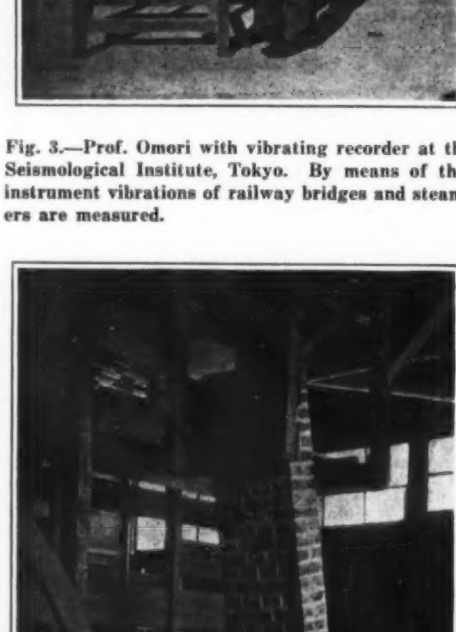


Fig. 4.—"Shaking table" in the Seismological Institute, Tokyo University. The bricks are made specially for testing purposes from brick columns previously destroyed by earthquake. They are pulled asunder in order to find out the strength of the brick and mortar joint.

important than thickness of walls. Now, in the Punjab the houses were built solidly enough, the walls being 2 feet thick, but they were filled up with rubble and small stones, and were, therefore, bad from an earthquake point of view.

Prof. Omori speaks very decidedly with regard to the responsibility of Government in the erection of jails and barracks, and he used a stronger expression than the writer ever heard before on the lips of a Japanese in critizing Occidental methods, when he said, in conclusion: "It is *almost criminal* on the part of the Government to build bad structures for public purposes, such as schools jails and barracks, and my advice to the Indian government would be to build more substantially, always on a sure foundation, with good binding either of wood or iron, and to use good material, especially in the case of public buildings."

In Calcutta, Prof. Omori found that the theory of the engineers was, that the soft soil of Calcutta acted as an elastic cushion, and, by absorbing the earthquake motion, prevented it from being communicated to structures standing upon it. Now this was quite an erroneous idea, earthquake motion being invariably felt more in soft than hard ground; and even within the confines of the city of Tokyo a shock varies considerably, one in the upper part being one half less in intensity than it is in the lower and softer parts. The same fact was also made evident in San Francisco, where at the time of the earthquake "made ground" and soft land suffered more than the hard.

Speaking generally, the most important principle in construction is to make the structure *a single body*, simple and compact, avoiding the possibility of different parts assuming different movements or vibrations. For example, chimneys are dangerous, because a chimney vibrates differently from the main building, and in the event of earthquake it will be found that a chimney is always broken at its junction with the roof; so that, as the fracture of a brick column occurs at a joint, its seismic stability ought to be increased by using good mortar, until the strength of the joint becomes equal to that of the bricks themselves. In 1894 a curious earthquake occurred in Tokyo, during which several chimneys were knocked down in barracks, factories, and schools, killing many soldiers and others. To obviate this danger the Japanese now make the part above the roof of light material, such as sheet-iron, or better still, of earthenware (*dokwan*). As a matter of fact, Tokyo is rendered generally hideous by these iron chimneys—perfect abominations, which tower above the roof-line, and are, indeed, made so long that, when they fall, they do not crash through the roof, but topple over into the street or garden beyond.

In Japan, it is interesting to note that ancient castle walls, built several hundreds of years ago, have forms approximately equal to the curve theoretically giving the greatest stability against earthquake, known geometrically as the parabolic curve. We find that the walls of all old castles are made of parabolic section, thicker at the base, in the form which mathematically gives uniform strength throughout the height and prevents the formation of cracks; and, as a matter of fact, all these castles have withstood terrific shocks of earthquake.

There is no better example in the whole country than the walls of Nagoya Castle (see Fig. 7), which are built of polygonal blocks, ten, twenty or thirty feet long, uncemented, and fitted into the bank at an even slope; and yet, after hundreds of years of storm and earthquake, there is scarcely a crack to be seen. They withstood the great earthquake in 1892, when thousands of houses fell in Nagoya and Gifu, and in the smaller places

Fig. 5.—The Earthquake-proof Building erected in the grounds of the Imperial University, Tokyo.

round about, and when all the new brick telegraph and post-offices and other European buildings came crashing down like ninepins. On that occasion, Japanese houses did not fall, unless they were old and frail, when in many cases the supports gave way and the roof came down, imprisoning the inmates until they were rescued, sometimes from a house in flames. The walls of the Castle of Tokyo show the same remarkable state of preservation, the blocks of cyclopean masonry, there also uncemented, being neither cracked nor displaced in the least degree.

Fig. 5 represents an earthquake-proof structure erected in the grounds of the Imperial University, Tokyo, which has been built according to mathematical calculation on a solid concrete foundation, and is intended for use as a Seismological Observatory, and as a standard with which to compare the effects of a shock on ordinary brick buildings. In it most interesting investigations into the stability of various structures against earthquake shocks are carried on, artificial earthquake motion being produced by means of a "shaking table," which can be made to move with independent horizontal and vertical motions by the use of steam engines. (See Fig. 4).

Another remarkable fact in Japan is that pagodas (see Fig. 1), built hundreds of years ago embody the principle of the modern seismograph, which is to minimize the effect of earthquake motion by the combination of an inverted pendulum with an ordinary pendulum; or, in other words, by the union of a stable and an unstable structure, to produce a neutral stability which renders the whole building least sensible to earthquake shock. In the hollow well of every five-storied pagoda a heavy mass of timber is suspended freely, like an exaggerated tongue, from the top right to the ground, but not in contact with it, and at the shock of an earthquake this large pendulum slowly swings the structure sways, and then settles back safely to its base. This is also the principle followed in the construction of all bell-towers throughout Japan, where the bell acts as pendulum, and the roof, supported by posts, forms an inverted pendulum, as in the seismograph. When an earthquake occurs, a pagoda or a bell-tower may be rotated or displaced, but it cannot be overturned as a whole. (See Fig. 2.)

Although seismologists have not yet succeeded in finding out any means of definitely predicting the occurrence

Fig. 6.—Earthquake crack three feet wide, made during the great earthquake in the Yamogata prefecture (North Japan).

of an earthquake, they are very hopeful of finally arriving at this desired goal; and already Prof. Omori, with his deflectograph and vibration measurer, can discern danger by careful observation of the pulsations which are always gently agitating the surface of the earth, and can usually give ten or twelve hours' notice of a shock. A sudden cessation of the regular heart-beats or pulsations of the earth's crust is a danger signal, extreme stillness invariably preceding an earthquake, whereas constant tremors are a good sign.

A great earthquake is almost always followed by weaker ones, and when it is violent and destructive the number of minor shocks following it may amount to hundreds, or even thousands, and continue for several months or years. The occurrence of after-shocks is quite natural and necessary for the settling down into stable equilibrium of the disturbed tract at the origin of disturbances each of these shocks removing an unstable or weak point underneath. Further, as a very great shock would remove a correspondingly great underground instability, it is probable that such a shock would not, for a long time, be followed by another of a magnitude comparable to its own, in the same or a neighboring district. When, however, the initial shock is not very great, it may be followed by another like it; but even in this case the position of the origin of the second shock would usually be quite distinct from that of the first.

It is a matter of common knowledge that a large part of the soil of Holland, with its villages and cities, is many feet below the level of the sea, and is slowly sinking, while

Fig. 7.—Nagoya Castle, one of the "sights of Japan." The walls are of parabolic sections, to give stability against earthquakes.

the Scandinavian Peninsular is in process of elevation. It is in this way that the great changes in the earth's surface take place in the course of ages; and the heory that mountain ranges, like the Himalayas, were suddenly thrust up by some world-shaking upheaval, has long since been dissolved by the light of experience and investigation. But while these mighty changes have come about unseen and unheard, the petty shakings of the seismic regions force themselves in a terrible way upon our attention, as in the appalling disaster of 1909 in Calabria and Sicily, one of the most awful of the recorded earthquakes of the world.

Earthquakes are of such common occurrence in Japan that they are hardly noticed unless some damage is done, and the writer was of en awakened in the night by the bed rocking from side to side, which sometimes caused a slight feeling of giddiness, like being at sea. She was also unpleasantly reminded of the forces at work at this seismic junction of the universe, when staying in the Yamogata Prefecture, in the north of the main island, where an unusually strong shock of earthquake was experienced. It lasted fully three and a half minutes, and although the house in which the writer was staying was not seriously damaged, there were cracks three feet wide in the ground near the windows (see Fig. 6). The building rattled and swayed as though Samson were beneath shaking it as a terrier does a rat, the surprised dogs outside began to bark and the cocks to crow, and the feeling of mysterious tremor or palpitation was distinctly uncanny. At the first indication all the Japanese rushed frantically into the street shouting, "*Jishin! Jishin!*" (earthquake) and stood huddled together in the utmost terror until the danger seemed over. The writer's own instinct was to sit tight and cling to the writing-table, but presently she found herself sliding on the floor with pictures off the walls and bric-a-brac—ancient and modern—strewn around. In Tokyo people mention earthquakes as we in England do the weather, when other conversation fails, and thrilling tales of personal experiences during the most appalling of all the operations of nature, are often told round a dinner-table in the metropolis.

The Mystery of the Predynastic Furnace Solved

By Marie N. Buckman, Secretary, Egypt Exploration Fund

(SEE OUR FRONTISPIECE)

The discoveries by the Egypt Exploration Fund at its famous site Abydos this past season clear up one obscure custom regarded as insoluble, identify the fourth dynasty cemetery, hitherto sought unsuccessfully, reveal a suspected necropolis 2,700 square feet in area of ibises buried with royal honors, and bring to light many rich treasures from early tombs Notwithstanding seventy years of excavation at wonderful Abydos these brilliant results mark the place still an epoch-making site. The present report concerns itself only with the solution of the furnace usage determined by a fortunate find when all hope of unravelling its mystery seemed gone.

In 1912 we found a remarkable kind of kiln in the temenos inclosure at the rear of the Temple of Seti. During the past year archæologists have exercised their ingenuity to account for its use in vain. This strange furnace or kiln was found on the edge of a predynastic settlement. It is composed of twenty-three large jars which still stand in the desert in two rows of eleven and twelve respectively. Each vase is coated outside with clay and supported with a number of brick fire-bars of varying lengths. Inside of each great vase and at its bottom rests a pottery dish into which was in some cases closely fitted another similar dish. Each dish has a crested bird incised on its outer surface. Around the two rows of kilns was found a wall of firebricks inclosing the whole furnace, and within this inclosure a fire had been kindled, of which considerable remains were visible. The whole had been covered in above at the edge of the rims of the vases with a layer of plain bricks. Only one

Near view of one of the furnaces.

conclusion was reached, that whatever was placed in these jars was to be kept at slow heat for a considerable time. The solution, which this year's discovery positively settles, confirms that decision.

This year T. Eric Peet, W. L. S. Loat, and Prof. Thomas Whittemore assisted by Prof. Camden M. Cobern, explorers working for the Egypt Exploration Fund, not only found eight more of the same species of furnace but succeeded in discovering their purpose. Mr. Peet, the director, graphically describes the notable find in his official statement to American headquarters at Tremont Temple, Boston: "The furnaces lie on a slight mound in the desert not 100 yards from the cultivation. Each kiln runs east and west. Each consists of two rows of large rough jars set side by side in the sand, each jar being supported by fifteen fire-bars of clay. The jars are about 50 centimeters in height and the same in diameter, though originally a little larger, as they have been a little denuded at the tops. The two rows of jars are, as it were, dovetailed into one another so as to get all the jars into as narrow a space as possible. The kiln thus forms a long narrow rectangle containing in the most complete case 37 jars, 19 in one row and 18 in the other. Round the whole was built a wall of pieces of fire-bars evidently from an old disused kiln, the wall reaching almost the level of the top of the jars. There had been a roof of which small portions remained and at intervals there were stoking holes in the walls. The fire was lighted in between the vases and was fed from without through these holes. The fuel used seems to have been small branches and rushes. Fixed tightly in the bottom of

each jar was a small roughly hemispherical bowl of pottery

What is the purpose of these kilns? When Prof. Garstang discovered one some years ago at Mahasna he thought it was used to fire the great jars themselves, in other words he took it for a pottery kiln. In the kilns at Abydos the heat was certainly never sufficient to fire a vase and the small bowls placed in the jars show too that the latter were not being fired. The glazing process or the smelting of metal are both out of the question for the heat is insufficient, nor were the vessels, porous as they are, used to hold any liquid. The explanation comes from the remains found in the jars themselves. They were, of course, full of sand, among which were small pieces of a blackish organic substance which on microscopic examination proved to consist of grains of either wheat or rye. The kilns were therefore used to heat large masses of grain and were doubtless built at the time of harvest when the grain was roasted or parched in bulk. Thus the obvious explanation of the shallow dish in the jars is that it would prevent scorching or burning the grain at the bottom of the jar.

Almost all nations, especially primitive ones, have the custom of parching grain not only in order to eat it in the grain but also in order to facilitate the grinding. The first fruits of the Scriptures were generally green ears of corn parched in the ear, and this parching of the green ears is still done in the villages near Abydos when a family is short of corn and their harvest is hardly ready to reap. The ears are parched in the bread ovens, ground on a flat stone and made into bread.

The kiln found near the Osireion was on the edge of a settlement of the predynastic period. That found at Mahasna was too. Petrie found one though he did not recognize its nature, so damaged was it, in the predynastic settlement at Ballas. There, too, Quibell found some of the fire-bars used to make a lining to a predynastic tomb. The style of the pottery bears this out and the kilns can be without hesitation attributed to the earliest period of Egypt's history."

The Emission of Electrons from Tungsten at High Temperatures*

An Experimental Proof that the Electric Current in Metals is Carried by Electrons

By Prof. O. W. Richardson

THAT the carriers of the negative thermionic current from incandescent solids are negative electrons was first established by J. J. Thomson.[1] In 1901[2] the writer developed the view that this emission of negative electrons occurred by virtue of the kinetic energy of thermal agitation of some of the electrons in the solid exceeding the work which was necessary to overcome the forces which tend to retain them in the body and which prevent them from escaping at lower temperatures. This conception has proved a very fruitful one and its consequences have been verified in a number of ways. It has provided a quantitative explanation of the variation of the number of electrons emitted with the temperature of the body. It led to the prediction of a cooling effect when electrons are emitted by a conductor and a corresponding heating effect when they are absorbed. Both these effects[3] have since been detected experimentally and found to be of the expected magnitude, within the limits of experimental error. The magnitude and distribution of energy of the emitted electrons has been found by experiment to be that given by Maxwell's law,[4] in accordance with the requirements of the theory. Finally, the same general train of ideas has led to valuable applications in the direction of the theory of metallic conductors,[5] contact potential[6] and photoelectric action.[7]

It has long been known that ions are emitted in a number of cases in which solids react chemically with gases. The recent experiments of Haber and Just[8] indicate that the alkali metals liberate electrons when they are attacked by certain gases. It seems likely, from various considerations,[9] that effects of this nature would account for most of the emission from heated sodium which was measured by the writer.[10] In consequence of this conclusion, together with the results of a number of experiments which are at first sight in conflict with the theory referred to at the beginning of this paper,[11] the view appears to have become rather prevalent that the emission of electrons from hot bodies is invariably a secondary effect arising in some way from traces of chemical action. That this view is a mistaken one is, I think, conclusively shown by the following experiments which I have made with tungsten filaments.

The tests to be described were made with experimental tungsten lamps carrying a vertical filament of ductile tungsten which passed axially down a concentric cylindrical electrode of copper gauze or foil. The tungsten filaments were welded electrically in a hydrogen atmosphere to stout metal leads. These in turn were silver soldered to platinum wires sealed into the glass container. The lead to the copper electrode was sealed into the glass in the same way. The lamps were exhausted with a Gaede pump for several hours, during which time they were maintained at a temperature of 550—570 deg. Cent. by means of a vacuum furnace. The exhaustion was then completed by means of liquid air and charcoal, the tungsten filament meanwhile being glowed out by means of an electric current at over 2,200 deg. Cent. Most of the tests were made after the furnace had been opened up and the walls of the lamps allowed to cool off. They were always considerably above the temperature of the room on account of the heat radiated by the glowing filament.

The processes described are extremely well adapted for getting rid of the absorbed gases and volatile impurities which form such a persistent source of difficulties in experiments of this character. Unless some such treatment is resorted to, the metal electrodes and glass walls of these tubes continue to give off relatively large amounts of gas under the influence of the heat radiated from the filaments and it has always been possible that this evolution of gas might have played an important part in the electronic emission. The mode of treatment used, for which I am largely indebted to the experience and suggestions of Dr. Irving Langmuir, of the General Electric Company's Research Laboratory at Schenectady, N. Y., seems very superior to anything in this direction which has previously been published.

Tests have been carried out covering the alternative hypotheses as to the possible mode of origin of the electronic emission which are enumerated below:

1. The emission is due to the evolution of gas by the filaments.

The lamp and McLeod gauge were cut off from the rest of the apparatus by means of a mercury trap, the volume being then approximately 600 cubic centimeters. A filament 4 centimeters long giving a thermionic current of 0.064 amperes was found to increase the pressure from zero to $<1 \times 10^{-6}$ millimeters in five minutes. The number of molecules N_1 of gas given off is therefore $<2.13 \times 10^{12}$. The number of electrons given is $N_2 = 1.2 \times 10^{18}$. The number of electrons emitted for each molecule of gas evolved is thus $N_2/N_1 > 5.64 \times 10^{5}$.

In the above experiment a liquid air trap was interposed to keep the mercury vapor off the filament. In another experiment with a filament 8 centimeters long this was not the case and with a current of 0.050 ampere the pressure rose in thirty minutes to a value which was too small to measure, but which was estimated as less than 10^{-7} millimeters. The corresponding value of N_2/N_1 is 2.6×10^{8}. In this case the current was unaffected when the mercury vapor was subsequently cut off by liquid air (a change of 0.4 per cent would have been detected).

The magnitude of the above numbers effectually disposes of the idea that the emission has anything to do with the evolution of gas.

2. The emission is caused by chemical action or some other cause depending on impacts between the gas molecules and the filaments.

In a tube with a filament 1.4 centimeters in length and having 1.65×10^{-2} square centimeters superficial area the pressure rose to $<2 \times 10^{-6}$ millimeters in 5 minutes with an emission of 0.050 ampere. If the gas is assumed to be hydrogen, which makes most impacts, using a liberally high estimate of the temperature of the copper electrode which determines the temperature of the gas, I find that the maximum number N^1 of molecules impinging per second during this interval would be $<7.0 \times 10^{12}$. The number of electrons emitted per second would be $N_2 = 3.13 \times 10^{17}$. The ratio N_2/N^1 is thus $<4.47 \times 10^{4}$. If the putative hydrogen atoms simply turned into a cloud of electrons whose total mass was equal to that of the hydrogen the value of N_2/N^1 would be only 3.68×10^{3}. The data already referred to for the tube with the filament 8 centimeters long give an even larger ratio for N_2/N^1, namely, 1.57×10^{4}. Moreover, in some of our experiments the changes in gas pressure were much larger than those recorded above, but they were never accompanied by any change in the electronic emission; also the admission of mercury vapor at its pressure (about 0.001 millimeter) at room temperature produces no appreciable change in the emission. Thus there is no room for the idea that the emission of electrons has anything to do with the impact of gas molecules under the conditions of these experiments.

3. The emission is a result of some process involving consumption of the tungsten.

To test this question some of the lamps were sealed off after being exhausted in the manner described. The filaments were then heated so as to give a constant thermionic current which was allowed to flow for long intervals of time. In this way the total quantity of negative electricity emitted by the filament was determined. The wire was placed in one arm of a Wheatstone's bridge so that the resistance could be recorded simultaneously. The cold resistance was also checked up from time to time.

At these high temperatures the resistance of the filaments increases slowly but continuously. This increase is believed to be due to evaporation of the tungsten. It was found to be proportional to the time of heating when the thermionic current was kept constant, in the case of any particular filament. In the case of one filament which gave 0.05 ampere for 12 hours the increase in the resistance of the hot filament was 9 per cent. The accompanying proportionate increase in the cold resistance was slightly lower, namely, 7 per cent. The latter may probably be taken as a fair measure of the amount of tungsten lost by the filament. The increase in resistance of the hot filament, which is less favorable for our case, will be considered instead in the following experiment for which the other data are lacking.

A filament 3 centimeters long gave 0.099 ampere electronic emission continuously for 2.5 hours. The resistance when hot rose from 4,773 to 4,787 in arbitrary units. The number of atoms of tungsten lost by the filament in this time was $= 5.66 \times 10^{15}$, while the number of electrons emitted $= 5.57 \times 10^{21}$. The number of electrons emitted per atom of tungsten lost was 9.84×10^{7}. The mass of the electrons emitted in this experiment was thus very close to *three times* the mass of the tungsten lost by the filament.

This tube gave 0.1 ampere electronic emission on the average for 6 hours altogether. By that time the mass of the electrons emitted was approximately 2 per cent of the mass of the tungsten filament. The tube came to an end owing to an accident: the filament gradually became deformed until it touched the copper electrode and broke. The hardness of the tube was then tested with an induction coil and the equivalent spark gap was found to be 3.3 centimeters. The discharge

* Reproduced from *Science*.

[1] *Phil. Mag.*, vol. 48, p. 547 (1899).

[2] *Camb. Phil. Proc.*, vol. 11, p. 286 (1901); *Phil. Trans.*, *A*, vol. 201, p. 497 (1903).

[3] Richardson and Cooke, *Phil. Mag.*, vol. 20, p. 173 (1910), vol. 21, p. 404 (1911); Cooke and Richardson, *Phil. Mag.*, vol. 25 624 (1913).

[4] Richardson and Brown, *Phil. Mag.*, vol. 16, p. 353 (1908); Richardson, *Phil. Mag.*, vol. 16, p. 890 (1908); vol. 18, p. 681 (1909).

[5] Richardson, *Phil. Mag.*, vol. 23, p. 594 (1912); vol. 24, p. 737 (1912).

[6] Richardson, *Phil. Mag.*, vol. 23, p. 636 (1912).

[7] Richardson, *Phil. Mag.*, vol. 24, p. 570 (1912); Richardson and Compton, *Phil. Mag.*, vol. 24, p. 575 (1912).

[8] *Ann. der Phys.*, vol. 30, p. 411 (1909); vol. 36, p. 308 (1911).

[9] Cf. Fredenhagen, *Verh. der Deutsch. Physik. Ges.* 14 Jahrg. p. 384 (1912); Richardson, *Phil. Mag.*, vol. 24, p. 737 (1912).

[10] *Phil. Trans.*, *A.*, vol. 202, p. 497 (1903).

[11] Cf. Pring and Parker, *Phil. Mag.*, vol. 23, p. 192 (1912).

through the tube gave a bright green fluorescence on the glass around the negative wire, but there was no indication of a glow or the faint purple haze which is obtained when traces of gas are present in tubes of this kind. There is thus no appreciable accumulation of gas even when the filaments are allowed to emit a large thermionic current continuously for a long time.

Another tube with a wire 2.7 centimeters long, giving 0.050 ampere, lost 1.19×10^{17} atoms of tungsten in 12 hours as measureed by the change in the cold resistance. The number of electrons emitted for each atom of tungsten lost was thus 1.13×10^{6} and the mass of the emitted electrons about one third of the mass of the tungsten lost. This tube ran altogether for about 23 hours, giving various currents, and finally gave out, owing to the local loss of material near one end, caused by the sputtering or evaporation. Local overheating is very apt to occur in these experiments as the thermionic leakage causes the heating current in the wire to be bigger at one end than the other. The mass of all the electrons emitted by this filament was equal to 4 per cent of its total mass. Under a low-power microscope the filament did not appear to be much changed except in the region where it had burnt out, where it was much thinner than elsewhere.

There is no known reason for believing that the loss of tungsten is due to anything more profound than evaporation. But, in any event, the fact that the mass of the emitted electrons can, under favorable circumstances, exceed that of the tungsten loss proves that the loss of tungsten is not the cause of the electronic emission.

4. The only remaining process of a similar nature to those already considered which has not been discussed is the bare possibility that the emission is due to the interaction of the tungsten with some unknown condensable vapor which does not affect the McLeod gauge. This possibility is cut out by the fact that the thermionic emission is not affected when the liquid air and charcoal is cut off and the vapors allowed to accumulate in the tube, and by the fact that very considerable changes in the amount and nature of the gases present (as by the admission of mercury vapor) have no effect on the emission.

Taken together these experiments prove that the emission of electrons does not arise from any interaction between the hot filament and surrounding gases or vapors nor from any process involving consumption of the material of the filament. It thus follows that the emission of electrons from hot tungsten, which there is no reason for not regarding as exhibiting this phenomenon in a typical form, is not a chemical but a physical process. This conclusion does not exclude the possibility that, under other circumstances, electrons may be emitted from metals under the influence of various chemical reagents, a phenomenon which would be expected to exhibit the same law of dependence upon temperature; but it does involve a denial of the thesis that this emission is invariably caused by processes involving changes of material composition.

The experiments also show that the electrons are not created either out of the tungsten or out of the surrounding gas, but that they flow into the tungsten from outside points. The experiments therefore furnish a direct experimental proof of the electron theory of conduction in metals.

The Modern Production of Lampblack*

How It Is Automatically Precipitated and Collected by Electricity

By B. Thieme

The production of lampblack is an industry which has of late years acquired much importance, as lampblack has come into use in many processes in which it was previously not thought of. One industry which consumes considerable quantities of it is the manufacture of electric light carbons, though here only an inferior quality of the product is employed.

As the demand for lampblack was found to increase, endeavors were made to improve the very uneconomical processes of manufacture then in vogue, which gave only about 20 to 30 per cent yield figured on the carbon in the raw material.

There are essentially two different methods for the manufacture of lampblack. One of these is based upon the production of soot from flames, the other upon the decomposition of gases and liquids by electric or other means.

One of the earliest electric patents for the production of lampblack depends on the observation that hydrocarbons are decomposed with deposition of carbon when exposed to the electric spark.

Such processes in general furnish a good quality of lampblack if the decomposition proceeds at a comparatively low temperature. But if the decomposition is more or less explosive, as is unfortunately the case in the majority of instances, the lampblack is raised to a high temperature, and its quality as a pigment is thereby impaired. The high temperature deprives the lampblack of its volatile constituents, which are very essential in printers' ink, and becomes hard and floury, with poor binding properties. The addition of other ingredients to overcome these defects is unavailing.

In the ordinary process of producing lampblack by incomplete combustion with limited air supply, the carbon which is collected at the end of the flame must traverse its entire length on the way, and is thus raised to rather high temperatures, which nevertheless do not attain that of explosion. The temperature of such a flame can, in fact, easily be determined, and is found to be about 1,500 deg. Cent. Hence, this process generally furnishes a fairly good product.

The simplest expedient, of course, would be to cool the flame as much as possible, and in point of fact this is the common practice. Usually the flame is passed through a water-cooled funnel or stack which presents a large cooling surface. But there is an obvious limit to the cooling which can thus be effected, as a certain heat is required to maintain the combustion and to gasify and preheat the fuel. If the cooling is carried further, the flame is extinguished, and the temperature at which this occurs is comparatively high.

A new process recently invented follows a different plan. Here lampblack (soot) is caused by electrical means to separate out in the flame itself, which has the double effect of conservably cooling the flame, and at the same time increasing the production of soot. As the soot is precipitated electrically against the flame, a constant supply of fresh soot is formed at its surface, and this prevents the lampblack when once formed from being impaired by the heat. Moreover, the precipitation is a rapid process, so that the soot is not long exposed to the influence of the flame. The lampblack thus obtained is accordingly of high quality, being intensely black and making a first-class printers' ink.

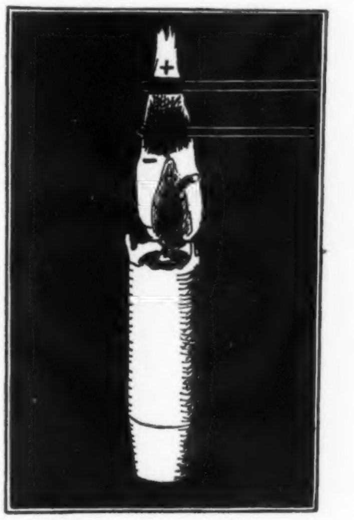


Fig. 1.—Electrical precipitation of lampblack from candle flame.

Fig. 1 shows the electric precipitation of lampblack as applied to a candle flame. If two poles of a source of electricity (at about 15 volts) are introduced close together into the flame, as shown in the illustration, a deposit of soot is formed at the pole. This deposit grows out in the direction of the course of the gases. If looked at through a magnifying glass the precipitate presents the appearance of a huge polyp stretching out its arms in search of prey.

Fig. 2 shows an arrangement for carrying out on a technical scale the process just described. This comprises a square hearth measuring about 20 inches on each side and formed of pipes with numerous perforations. Above this hearth two sheets of iron wire netting are spread, the upper one being hinged so that it can be tipped out of the way. The space between the two nets is about one inch; their distance from the hearth is such that the flame strikes through them. The upper net is connected by an iron block Q and a relay R to a high tension source of 220 to 400 volts, direct current. If alternating current is to be used the arrangement must be modified somewhat.

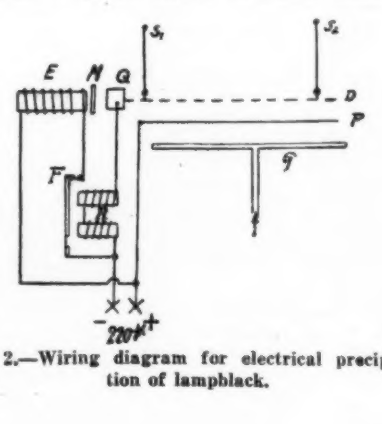


Fig. 2.—Wiring diagram for electrical precipitation of lampblack.

The apparatus works as follows: When the current is flowing, and the flames of hearth G are burning against the wire netting, a precipitation of soot sets in at the upper net D. This deposit grows, principally upward, but to some extent also downward, toward the lower electrode, in the space between the two wire nettings. The current is quite small, only about one ten thousandth of the current consumed by an ordinary incandescent electric lamp. This current is therefore too weak to actuate the relay R through which it flows. But as the last deposit between the two nettings grows, presently contact is made between them, and a comparatively strong current now flows through the relay R, whereby the contact spring F is drawn toward the contact piece of the relay, thus closing the circuit which energizes the electro-magnet E. In consequence of this the iron block Q is violently pulled against the pole of the magnet E, and, as this block Q is connected to the netting D, the latter is severely shaken, and the soot deposit adhering thereto is detached and is collected in a space provided therefor. At the same time the electrical connection between the two pieces of wire netting is broken, the relay R ceases to act, spring F is released and the core E is demagnetized. A brass plate M prevents block Q from permanently adhering to magnet E, so that netting D returns to its normal position, and the process starts over again as at the beginning.

In this way lampblack is very efficiently produced by electrical means. Moreover, the product is free from hard lumps frequently found in products from other processes, and is very fine in structure.

The only attendance required is the periodic removal of the deposit of lampblack on the lower netting, which is carried out at intervals. In large plants care must be taken to prevent red hot lampblack from getting into the collecting trough and setting fire to the product accumulated therein.

* Translated for the Scientific American Supplement from the *Elektrotechnische Zeitschrift*.

The Speed of Glaciers

"The Speed of Glaciers in Winter and the Inanity of the Thermic Theory of their Progression," such is the title of a study that has just been published by M. Vallot, Director of the Mont Blanc Observatory. From the numerous observations made by M. Vallot at the "Sea of Ice" in the *massure* of Mont Blanc, it appears that no calorific variation either diurnal or annual can penetrate into the interior mass of the glaciers, and that it may be considered as a river that is flowing on in its bed under the simple influence of weight, with a speed that is not sensibly different in winter from what it is in summer.—*Chemical News*.

A group of the English army medical service in the fly bush. Medical heroes who have taken their lives in their hands for the benefit of humanity.

Sleeping Death

The Scourge of Africa

By Day Allen Willey

We know the wonderful success of medical science in discovering the causes of yellow fever, malaria, typhoid, tuberculosis and other diseases dangerous to humanity, and in reducing their ravages and adding to the average length of life.

But one of these invisible foes to man remains unchecked, although for over a quarter of a century some of the world's greatest medical men have lived in the tropical swamp and jungle, enduring hardship and danger to learn what can be done to kill the trypanosome that causes sleeping sickness. No injection or application of the hundreds thus far conceived has resulted in destroying this paralyzer of the nerves and decayer of the blood.

Hunting for larvæ of the tsetse fly in an African swamp. The negro on the bridge is on the watch for flies which may be in the air.

Sleeping sickness can better be termed sleeping death, for every victim, once afflicted with it, becomes deadened by a torpor which, sooner or later, turns the unconscious body and mind into a thing of death.

If the Garden of Eden were again discovered, Africa might claim it. Lake Victoria with its clusters of islands is still to the eye a paradise of the Dark Continent. The Sesse Islands in that lake are a specimen of Nature's jewelry.

But, exquisite as is their scenery, the Sesses form a charnel house. Death is over them. This is a land of silence. The voice of the child is unheard, the chant of Baganda women, so full of cadence, comes no more over the waters. The bark hut villages that for centuries sheltered the finest types of the African race, in mind and body, are rotting ruins. Why this desolation of all that is human? Because of a sleeping death. What causes the sleep that kills? A fly that breeds the tiniest murderer known to the world, a murderer that never fails to kill its victim whether human or animal, and whose life means certain death wherever it lives.

The tsetse looks like our house fly that has been accused of so many crimes. There is nothing about its appearance to indicate its deadly character. The hollow, boring tool, its weapon, is invisible to the naked eye, and the point is so keen that its incision is painless. The fly gets its death-dealing microbes from biting the mouths of crocodiles, hyenas, lions and other wild beasts and reptiles, parasites that are fatal only to human beings, and swarm in animal blood without affecting the host. Such blood is the food of the fly. On the Upper Nile, Dr. Nabane saw crocodiles sunning themselves. Upon the highly vascular lining of their open mouths were literally swarms of tsetses.

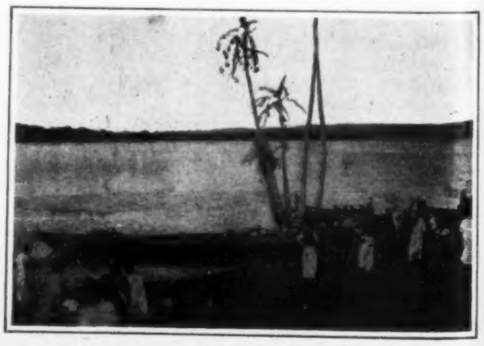
Eight species of these winged destroyers spring from larvæ buried in the mud banks of streams. The one that menaces human life is the Glossina. When it has sucked blood filled with trypanosomes, it has enough to last it 66 days. During this time, man, woman or child on which it alights, may become its victim. It lurks in the grass and amid the flowers of the swamp, and will fly sometimes a hundred miles in a day.

And here is the startling prediction of Sir David Bruce, one of the pioneers in the war of medicine against sleeping sickness, who has chanced death for years in his devotion to what is his life work: "While so far it has claimed comparatively few white victims, not only do the blacks easily become infected, but whites who get it die of it. Does the civilized world realize what a terrible sacrifice of human life might ensue if the sleeping sickness should contrive to steal across to European, American or Asian shores? Such disaster is not impossible, as is proved by the fact that often cases have not developed until months after any supposed possibility of infection, and by the further fact

Crocodile on which the flies suck the death mites from the flesh of the jaws. A number of flies were found on this specimen by the doctor who killed it.

Type of the Baganda tribe on the shore of Lake Victoria. These people were literally exterminated by sleeping sickness and caused the world movement to investigate it.

In one of the infested districts. Sir David Bruce, head of the sleeping sickness fighters, who has learned more about the disease than any other authority.



One of the Kibanga landing places, where the natives of the Sesse Islands came to sell pottery and vegetables. Photograph taken before the sleeping sickness raged. The place is now deserted.

Sir David Bruce (on extreme left) in the laboratory of a detention camp, making microscopic examinations of trypanosomes and dissecting the tsetse flies.

Army medical laboratory in Uganda, where examinations are made of the insect killer to discover some means of fighting the deadly pest they carry.

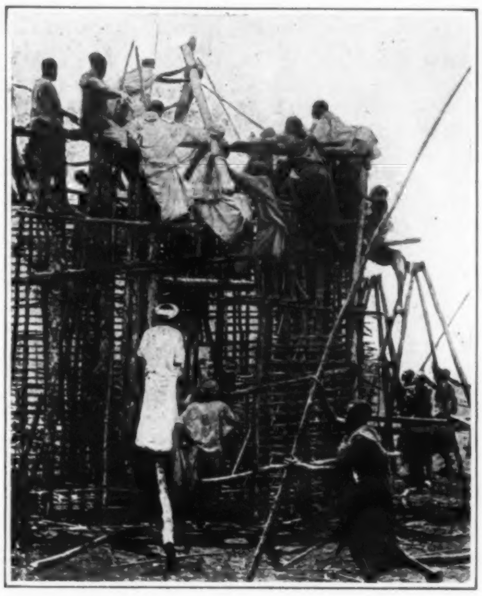
that it is not yet definitely known that the mosquito or some other fly than the tsetse may not communicate the disease. If the world knew what we know, scientific columns would be hastening to the front from all the great powers, bent on a joint assault of the enemy before it was too late."

Out of the many thousands of victims treated with every possible remedy, not one has ever recovered, and to-day when the tsetse fly drills its beak into the human body it never fails to instill the death-dealing enemy. When Livingstone went along the caravan trails and through the central African wilderness, years ago, the tsetse fly was boring into its victims and putting the touch of death in their blood. The great naturalist thought of arsenic as a last resort. It was a case of kill or cure, and was injected into the veins, but the mite survived. For 25 years the chemists and world-known doctors have worked in the laboratory to create some drug that would destroy it, but in every case death came, sometimes in a year, sometimes not for several years.

Around Victoria and on its islands lived the Bagandas, where the sleeping death has claimed thousands of victims in this earthly paradise. Following the first explorers of it, came the men of the church. They visited the thatched villages of the Baganda, the most intelligent negroes of their race. They seemed to be strong and healthy, but their appearance was deceptive. A missionary on his rounds sometimes came across a native who seemed to be lazy. He would lie or sit in the sun with eyes fixed on the ground in a listless stare. The missionary thought little of it.

Then one of the British army surgeons who had once ventured in the Congo swamps, where the tsetse fly has done its work, noticed something about a child that made him look more closely. Without a stitch of clothing on, the little one was sitting on a bit of grass waving its arms up and down while it laughed, as only the negro child can laugh. The doctor walked around behind it, and closely examined the glands in the back of the neck, hurried to the house of the commandant of the station, and took him into an inner room, and whispered a few words. Hurry calls were sent to the officers to come to the commandant at once. "You will take squads and bring every native to the settlement. Do not let one get away. The doctor has found a case of sleeping sickness, and we must examine all."

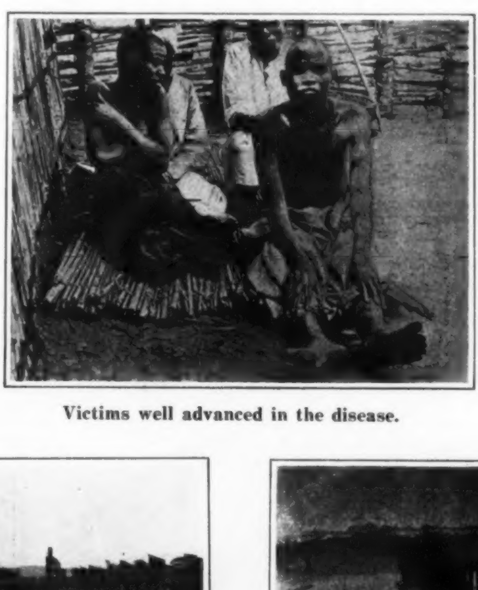
Every surgeon at the post joined in the search, and out of nearly a thousand Bagandas, the gland test showed that over twenty in one hundred had death in their arteries. In the twelve years since the doctor found the infected child in Uganda a half million human beings on the Sesses and the



Erecting a detention camp for tsetse victims.

shores of Victoria have been the victims of this diminutive murderer.

Not only Bruce, Hardy and Klein, world-known medical experts, but Nabarro, Todd, Koch, Hodges, Kopke, and Martin have taken the death chance and are among the little band on the very front of the fighting line, hopeless yet of relieving the



Victims well advanced in the disease.

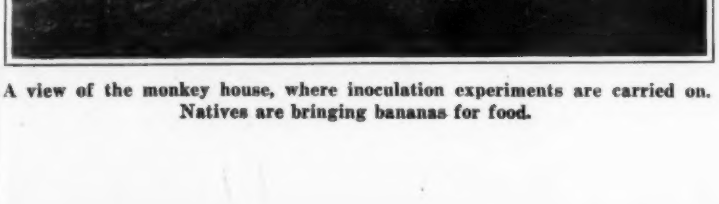
victims of the trypanosome, but struggling to prevent its further destruction of the human race. Nabarro has devoted most of his life in trying to conquer the thing invisible; to discover a remedy he must spend years in the region now known to be deadly to black or white. He has gone into the worst plague spot of the infested Africa, the Congo Free State, from where came the death fly to Uganda, when Emil Pasha's Soudanese, corrupt and diseased, entered the country and left a trail of fire and blood. Worst of all, the flies from their caravans infected the people and the rapid spread of this physical curse caused more harm than their ravages.

When a negro is silent it means that something within is wrong. This was one way in which the doctors found the beginning of the death sleep, where there was no other sign. When the song stops he seems to get lazier and lazier. His vigor has gone. As he walks he staggers. After a while he may crawl, no strength in his legs to support his body.

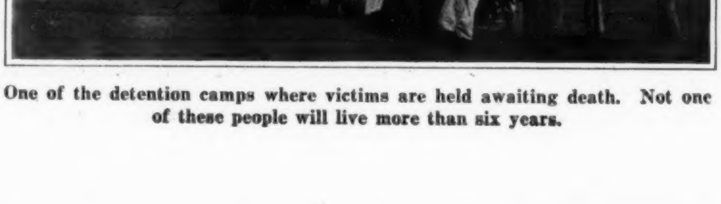
Now the neck glands stand out, his eyelids half close over the dimmed eyeballs. He is a picture of a human being turning into an unnamable thing, and as he grows weaker and weaker, the face becomes more and more distorted. That wriggler in his blood, unknown to him, is slowly deadening brain as well as body. The stronger the victim the longer he resists, but finally his efforts cease. Limbs and arms are bent at the knee and elbow and become rigid. The dull, fixed, half-closed eyes have no movement. Inside the body is life, the heart is beating, the stomach can digest food, but the outside is dead.

The invisible murderer at last has entered the spinal canal and has multiplied in it. Paralysis has the victim in its grip. But months, even years, may pass and still the heart beats, though this human thing is blind, dumb, immovable. It has no pain. It has no feeling. A torpor has enveloped it. Not a sound can it utter. At last the death sign comes. The head of the patient, who generally lies with his back propped against a wall or post, bends forward, at first only an inch or so. The neck muscles are weakening. Lower it falls until the chin rests on the breast. The heart beats fainter and slower, and stops. The trypanosomes have finished their work. He is a corpse, infected with the parasites which have killed him, and a source of other deaths should the tsetse bore into the body. Cremation or burial occurs at once.

Here and there in western Uganda, far enough away to be free from the fly's visits, are the detention camps, where the "suspects" are herded after being brought in droves, to be placed where they cannot infect others. Before they are placed in



A view of the monkey house, where inoculation experiments are carried on. Natives are bringing bananas for food.



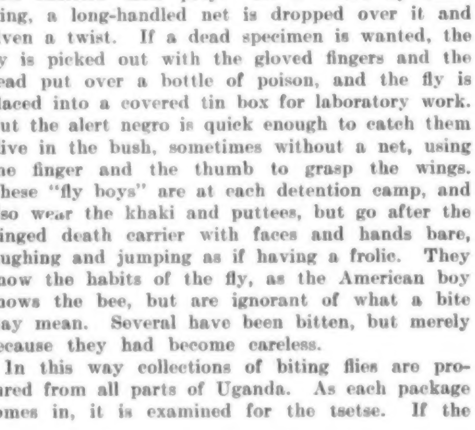
One of the detention camps where victims are held awaiting death. Not one of these people will live more than six years.

The death carrier that injects the invisible murderer into the human body.

these thatched sheds, the surgeon's needle pierces each and fills the test tube with blood on which the microscope must pass judgment. If even a single parasite is detected, the negro is condemned to confinement for life. He can go outside the shelter if able, walk or sit as he wishes. But there is a dead line where are posted black men in khaki and puttees, Uganda native guards, drilled to handle the rifle. If one of these prisoners for disease in his frenzy attempts to pass between those living statues he is seized and forced back. If he should get outside, the blacks obey their orders, but this death is a mercy if the victim had the intelligence to know it. Thus, the spread of the disease has been checked at least in Uganda.

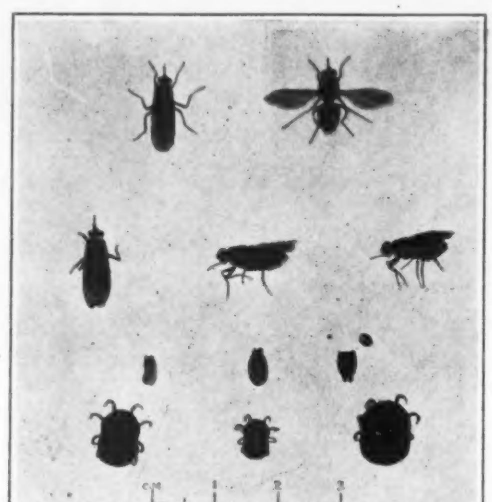
The captives in the detention camp, the monkey huts, the rat cages, the dog houses, provide means of studying sleeping sickness by which many of the facts known of its curse to human beings and animals have been revealed. Risking their lives, the members of the fly expeditions search swamp and water shore, where the rank tropical vegetation shelters their prey. As a tsetse fly takes wing, a long-handled net is dropped over it and given a twist. If a dead specimen is wanted, the fly is picked out with the gloved fingers and the head put over a bottle of poison, and the fly is placed into a covered tin box for laboratory work. But the alert negro is quick enough to catch them alive in the bush, sometimes without a net, using one finger and the thumb to grasp the wings. These "fly boys" are at each detention camp, and also wear the khaki and puttees, but go after the winged death carrier with faces and hands bare, laughing and jumping as if having a frolic. They know the habits of the fly, as the American boy knows the bee, but are ignorant of what a bite may mean. Several have been bitten, but merely because they had become careless.

In this way collections of biting flies are procured from all parts of Uganda. As each package comes in, it is examined for the tsetse. If the



By courtesy of *Knowledge* From a drawing by Count L. de Sibour

Trypanosoma gambiense. **The most salient structural details of a trypanosome. Note the long flagellum, by lashing which the micro-organism propels itself along.**

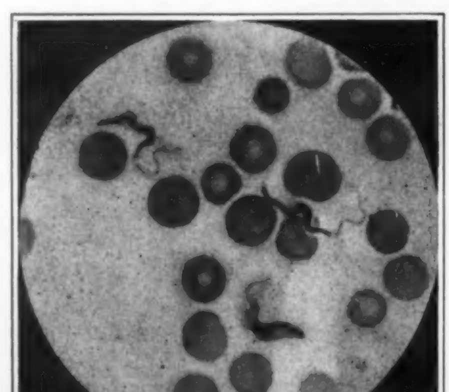


The life of the tsetse from birth to full growth. The view shows the larva, pupa, and the development. At the top is the full grown fly at rest and flying. Natural size.

parcel contains man killers, a red disk is stuck on a large map over the locality from which the flies have been sent. If, on the other hand, no tsetse flies were found, a blue disc is fixed over the spot. In the same way, and at the same time, a second map is prepared to show the distribution of sleeping sickness. If a note accompanying the collection of flies states that sleeping sickness is prevalent, then a red disk is placed over the locality, and if, on the contrary, no cases of sleeping sickness are reported, a blue disk is affixed. Thus the two maps so prepared show at a glance whether the distribution of sleeping sickness and that of the tsetse correspond or not, and the map warns against the infected regions.

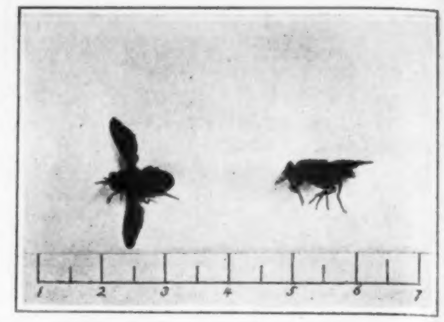
The tsetse, dead or alive, is made an agent to aid in finding a cure for the fatal mite which it carries. The dead go to a dissecting stand where the microscope reveals the number of trypanosomes each has in its mouth, if infected. Larvæ collected are hatched in an incubator and the changes observed up to the adult age. To prove its ability to do its murderous work, the fly developed is fed on a drop of infected blood and placed on a monkey to bite him. Once is enough. Blood tests soon show the wriggler in the blood of the animal. He can be counted as dead. Before the monkey dies, other flies are put into the monkey box to suck his blood, then taken to the dog house or the rat cage to discover if they are infected. The animal victims may show no outward signs, but again the blood tests reveal the deadly truth that the tsetse can carry its invisible death-dealing parasite from an infected animal as its source.

Can a drug be discovered which will cure a human being? Many attempts have been made, and are being made, to discover such a drug. As long ago as the days of Livingstone, arsenic was vaunted as a cure of the "fly disease," and up to the present time this drug has held its own as probably the most useful one. At first it was used in the form of arsenious acid, dissolved in an alkaline solution, but later other preparations, such



By Courtesy of *Knowledge*

Trypanosoma gambiense **from blood of rat. Smear fixed out with osmic acid vapor, and stained. A slender, a stumpy, and an intermediate form are seen in the field.**



Two positions of the tsetse fly, showing its proportions. Natural size.

as atoxyl and orpiment, have been experimented with. These experiments have in many cases been made on the lower animals, and some have been followed by a complete cure. But up to the present time there is no single instance of a cure effected in man, although thousands of cases have been treated. Experiments have shown that these parasites seem to completely disappear from the blood a few hours after administration of a dose of one of these drugs; and the effect of the treatment seems often marvelous, the patient regaining the appearance of health in a remarkably short time; but eventually the trypanosomes always return to the blood and the death sleep ends his life.

In conclusion the author wishes to say that in the preparation of this article he had the courteous co-operation of Sir David Bruce, the eminent British army surgeon in charge of the Uganda investigation, and Dr. Louis A. Seaman of New York, one of the leading authorities on this African plague.

Slate and Shale Used in Manufacture of Paints and Linoleums

SLATE and shale are used to a considerable extent in the manufacture of pigments and as fillers in the manufacture of oilcloth and linoleums, the total quantity used for this purpose in 1912, according to the United States Geological Survey, being 20,964 short tons, valued at $121,482. This was an increase of 4,454 tons in quantity and of $16,031 in value over the output for 1911. The 1912 output of slate and shale used for paints and for fillers came from Pennsylvania, New York, New Jersey, Indiana, California, and Georgia, named in the order of their production, Pennsylvania producing over 84 per cent of the total output in the United States. The shales which are used in the paint trade are classed as black, yellow and red shales.

Scene in one of the laboratories where the flies are kept and studied. The glass cages on the shelves contain flies holding enough human destroyers to infect fifty thousand people.

Causes for Variation in the Quality of Distilled-Water Ice*

By Peter Neff

It is apparent to all that there is a great variety in the quality of distilled-water ice, some plants produce a superior grade while others in the same locality do not. This may be due to a multitude of reasons. There are, however, several simple ones which to a greater or less degree affect the quality, and some of these will be considered.

If pure distilled water could be placed in the cans, the ice would be practically clear and of a uniform quality. This condition cannot be realized in practice and all that can be hoped for is to approximate the ideal condition as nearly as possible.

Air in the water is an ever present trouble. If it has not got into the water before, it will do so when the can is being filled. The amount will vary with different tank men, because intentionally or otherwise, one man will so place the can and filler that a minimum amount of water will seal the end of the filler. Where the storage tank is placed so high above the top of the ice tank that there is considerable pressure at the filler, the inrush of the water to the can when the filler is opened will cause a large amount of air to be taken up by the water. This can be avoided by choking the flow to the can-filler hose.

A frequent source of air introduction is produced by draining the storage tank so low that the outlet is exposed, or so nearly so as to cause a suction of the air. There are times when the packing about the stem of the can-filler valve is not tight. When the filler is not in use a small leak may be observed at this point, which usually disappears when the filler is put into service, for the water in passing this opening will cause air to be drawn in.

The most fruitful source of air is the flat cooler, and sometimes the filter as well, when located above the storage tank. In such an arrangement there is a tendency at all times to suck in air through small leaks about the valve stems and joints. By putting water pressure on this part of the apparatus, the leaks may be located. All parts of the distilling system from the reboiler or skimmer to the storage tank should at all times be full of water under pressure.

Where the condition noted prevails, a regulating valve controlled from the reboiler or skimmer should be placed at a point below the bottom of the storage tank. And the opening through this regulator should not be so great as to allow the water to flow through faster than supplied from the reboiler or skimmer, for if it does it will produce a suction on the apparatus between the regulator and the reboiler.

Care must always be exercised to see that the reboiler is not allowed to drain, for when it does enough air is introduced to ruin all the water in the storage tank and in some cases to cause parts of the apparatus to become air-bound. The surest method is to have the flat cooler and filter below the bottom of the storage tank, which will insure their being full of water at all times, but even then it is desirable to have the regulator below the storage tank.

A little care in these particulars, remembering that falling water will suck in air when passing a small opening, will reduce air troubles to a minimum.

Air in the water is manifested in the ice by a white core with radiating needles. But air is not the only cause of white ice. Other gases generated in the boiler from impurities contained in the water used, pass with the steam and are taken up by the water when condensation takes place. Some of these gases have a disagreeable odor, so often noticeable in manufactured ice. A proper venting of the steam condenser will help to get rid of these gases. In other words, allow a small amount of steam to escape from the condenser at all times.

The object of the reboiler is to further eliminate these gases as well as the air, and for that reason the reboiler does better work when the depth of the water is small in comparison with the area of the water surface, so that the gases have a freer exit. In spite of these precautions some gas will remain in the water, and for this reason it is customary to filter the water through charcoal, taking advantage of its peculiar property to retain or occlude them. The capacity of charcoal for this purpose is limited, especially when some oil is passing with the water, as the oil tends to fill up the small interstices in the charcoal. When care is not exercised to thoroughly eliminate these gases in the condenser and reboiler, it is but a short time before the charcoal filter is of no use, although to the eye the charcoal may appear all right.

Of all these gases the principal source is the foreign matter contained in the water used in the boiler. Some gas may come from the oil used, but the greater quantity comes from the water. As the process of concentration goes on in the boiler, more of these gases are driven off, and the higher the temperature of the steam, corresponding to a higher pressure, the more readily will the gases be formed. To obviate this trouble, the boilers should be blown down frequently, and the steam pressure carried no higher than is necessary for the work and supply only the requisite amount of distilled water.

There is another trouble causing white cores and sometimes a white or cloudy appearance of the outside of the cake of ice, with clear ice lying just under it. This trouble also comes from impurities in the water used in the boiler. More or less water is carried along with the steam, and if the boiler is priming the quantity may be considerable. When this raw water contains certain impurities, they crystallize at the same time as the ice crystals are formed, and produce the cloudy appearance referred to, which is easily distinguished from the white ice produced by air. Other impurities concentrate in the center of the ice cake and go to make up the white core. A separator on the main steam line will help eliminate this trouble, which is also lessened by the frequent blowing down of the boiler.

* Reproduced from *Power*.

Cellar Space Made Available by the Use of Prismatic Glass

By James Chittick

In many factory buildings, and other places where productive industry is carried on, there is frequently to be found substantial cellar space which is put to no other use than for storage purpose.

Wherever cellars are to be found, be they under private

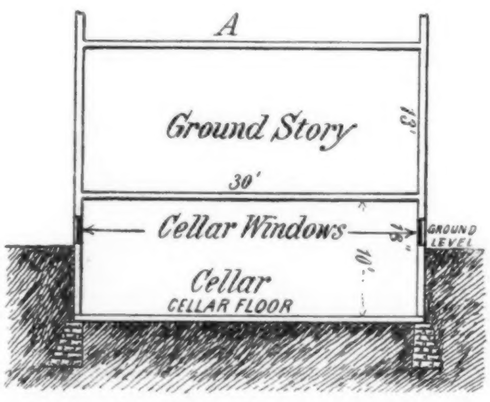


Fig. 1.—The original state of the building, with dark cellar space.

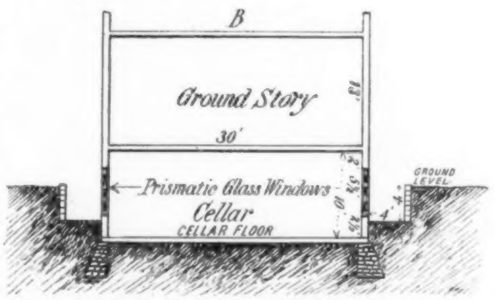


Fig. 2.—After alteration, with the cellar space made available for manufacturing operations.

houses, shops, or other buildings, this is generally the case, and the reason they are not put to more profitable uses is the absence of light.

Usually, the top of the cellar is two or three feet above the ground level, and in this limited space are placed small single windows at infrequent intervals, giving but little light at high noon, and, during most of the day, the place is half dark.

Many such cellars will have good head-room, say 8 to 12 feet, and have well-made floors, and, but for the absence of light, would be just as good manufacturing space as any other part of the mill. In fact, for textiles, the cellar space would be superior, on account of its damper atmosphere which facilitates the work.

It is no uncommon thing to find every other inch of habitable space jammed full, and yet spacious cellar room existing but largely unused.

There is a simple, and not very expensive method, that can in many cases be used to make this basement space fully available.

In the accompanying drawing, *A*, I have sketched part of a building, showing how the cellar was originally arranged, and in the drawing *B* I have shown what changes were actually made.

Along the side walls of the building are dug area-ways of convenient and suitable depths and widths. About 4 inches wide and 4 inches deep will often be found to answer very well.

The retaining wall may properly be made about 12 inches thick, with a good stone or cement coping on the top, reaching a trifle above the ground level.

The floor of the area-way may be laid with single brick, and, if there is a convenient sewer connection, it may be faced with cement and sloped toward the outlet to the sewer. If there is no sewer connection available, the bricks should be laid without mortar, so as to allow seepage between them to pass away rain water, and this will be helped if, here and there between them, holes are worked into the ground with a crowbar, so that the water can soak away faster through these holes. The level of this floor can be a few inches below the window sills, so as to prevent any chance of water entering the basement during heavy rainfall.

It is judicious to put braces across the area-way, at frequent intervals, to prevent the chance of the retaining walls caving in. A convenient form of bracing is to place iron plates on the two walls with lengths of 2-inch steam pipe between them. If these are made in two lengths, joined by a coupling, they can be readily tightened or lossened by turning the coupling.

Then the masons should break holes for windows in the cellar walls, at as frequent intervals as the structure of the building will permit, always taking care to keep on the safe side.

The size of these openings should be arranged to hold some regular stock size of window sash, say 5 to 6 feet high and proportionately wide, being the usual double sash with six panes in each half. Starting about 2 inches from the ceiling they might descend to 2 or 2½ inches from the floor. These sashes are bought unglazed, and, being stock goods, are quite cheap.

In the lights of glass to be used, that sort of prismatic glass that is rolled in large sheets should be procured. The makers of this will cut it to order, and they make them charge by the square foot and at a most reasonable price. Sufficient panes for the sashes are ordered, and are glazed in in the usual way. As the weight of this glass is greater than that of the common window glass, heavier sash weights should be provided.

The panes are cut so that the ribs run horizontally, and are glazed so that the smooth side is inside, and the prismatic face outside, the slope of the prisms being downward. In this position, also, they do not fill up with dust easily, and the rain helps to keep them clean.

A good sky-line is very desirable, that is, other buildings should preferably not be so close as to interfere materially with the light.

With an installation made as here outlined, it will be found that the glasses seize the rays of light and project them promptly across the room, making practically every inch of it available for all ordinary purposes and this also, to a great extent, even if it be only lighted from one side.

When lighted from both sides it may be advantageous to arrange that the new windows be not opposite each other, so as to avoid the conflicting of the beams of light.

This means of turning cellar storage space into good manufacturing space for textile work has been employed by the writer on several occasions, and always with the happiest results. If the rental value of the space thus made of use for manufacturing be compared with its value as storage room, it will be apparent that the sum of money spent in making the necessary changes has been made to yield a very handsome profit.

Hardening Steel with Compressed Air

A process whereby steel is hardened by means of compressed air is now in use by a German firm in cases where only certain parts of the metal require hardening. The customary methods of hardening by chilling the steel in water, oil, or special baths is not satisfactory in such cases, owing to the tension created between the hardened and unhardened portions of the treated metal. In the new procedure the compressed air is sprayed over the metal through specially designed nozzles, by means of which, by varying the number and spacing of the openings, the degree of hardening may be accurately graded. The claim is made that a wide range of results can be obtained by adapting the shape of the nozzle to that of the work.—*Journal of Industrial and Engineering Chemistry.*

A New Process for Coating Surfaces With Metal*

By Means of a Spray of Finely Divided Metal the Most Delicate Objects Can be Coated

By Dr. Lach

There are several methods of coating surfaces with metal now in vogue, of which the so-called "galvanizing" of iron (tin plate) and the electroplating of various metals are the chief. But each of these methods has its disadvantages; the latter, for example, is necessarily slow, and cannot be applied to some metals, as for instance aluminium. A new process developed by M. U. Schoop, of Zürich, is not only capable of much wider application than the former methods, but possesses other notable advantages, of which not the least is its extreme simplicity. It consists essentially in spraying the finely divided metal by a powerful blast against the surface to be coated. This surface may consist of almost any material—metal, wood, concrete, celluloid or even paper.

The production of fine metal powders by means of a spray is in itself not new, but has been practised for some thirty years. Thus the apparatus shown in Fig. 2 is employed for the production of powdered lead for accumulators. This apparatus is constructed like an ordinary atomizer, superheated steam being used to produce the blast which draws up the molten lead from a kettle.

But the idea of preparing, not a loose powder, but a

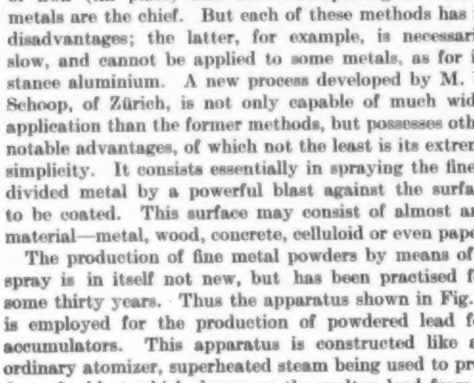


Fig. 1.—An earlier form of the apparatus devised by Mr. Schoop.

coherent coating of metal by such means, must be credited to the Swiss engineer, M. U. Schoop. The first apparatus by means of which this invention was carried out consisted either of a compressor or else of a compressed gas cylinder to furnish the requisite gas under pressure; this was then used much as in an atomizer to spray a stream of finely divided metal. At first a heated compressed gas was used, with the idea that such heated medium kept the drops of liquid molten, and that the molten drops coalesced on impinging against the surface presented to the spray. But it was soon discovered that the spray had a comparatively low temperature, so that it was quite possible to direct it not only against metal surfaces but against wood, paper and even celluloid without any danger of such material catching fire. Apparently then, the particles of metal were not molten at all on reaching the surface to be coated and the fact that they united to homogeneous layers upon the surface presented to the spray must be due to the effect of their impact and a high velocity (from 1,700 to 5,000 feet per second) against the surface presented to the spray. In fact, it was found that the pressure first employed—20 to 30 atmospheres—was altogether excessive, and at the present time a very much smaller pressure of only about 3 to 4 atmospheres is used. As a matter of fact it was found that the high pressure had the effect of causing the particles of metal to rebound from the surface to be coated, thus entailing an unnecessary and somewhat serious loss of material.

But the inventor did not stop here. The idea occurred to him that it might be preferable to start with the powdered metal and spray this after the manner of a sand blast against the surface to be treated. This was found to be perfectly feasible, and thus the apparatus was greatly simplified by eliminating the melting kettle. It was now possible to construct the apparatus on a comparatively small scale and to make it transportable.

But as yet perfection was far from being attained. The valves of the apparatus had to be very finely made and they were very apt to become stopped up by the metal dust. Besides, it was difficult to regulate the feed of metal and there was consequently considerable waste. It was impossible to work with the rare metals such as silver and gold in this way, as the weight was excessive, and the metals with high melting points could not readily be caused to coalesce in the process.

* Abridged translation prepared for the Scientific American Supplement from *Prometheus*.

Moreover, while the apparatus was portable, it was still rather heavy and clumsy. All these disadvantages have now been completely overcome, the apparatus in its present form being no larger than a pistol.

In its latest form the apparatus depends neither upon the use of molten metal nor of metal powder, but makes use of a fine metal wire which is led through the apparatus and atomized. Fig. 1 shows one of the earlier forms of this device. At *a* is seen a spool from which a fine metal wire is unwound by means of a mechanism *b*, which feeds it to the atomizing nozzle *c*. The apparatus is actuated through a transmission gear *e* from an air turbine *d* which is driven through a reinforced flexible pipe *f* by means of compressed air at six to eight atmospheres, making about 15,000 revolutions per minute. The nozzle is provided with connections *h* and *h'* for oxygen and hydrogen, which issue at the nozzle, are there ignited and fuse the metal wire as it is fed through the nozzle. The compressed air after passing through the turbine and there doing its work, passes by a tube *i* to the nozzle from which it issues as a conical blast surrounding the oxy-hydrogen flame and carrying with it the metal molten by that flame. The working of the apparatus is accurately regulated in such manner that the turbine feeds

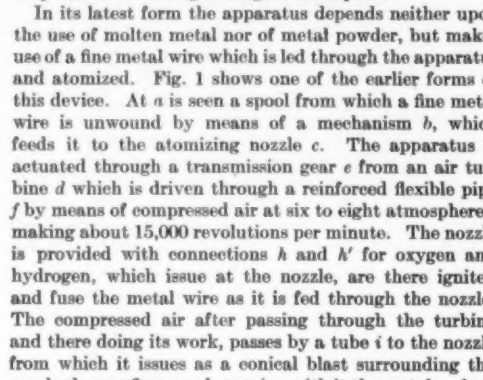


Fig. 2.—Diagram showing essential parts of metal atomizer.

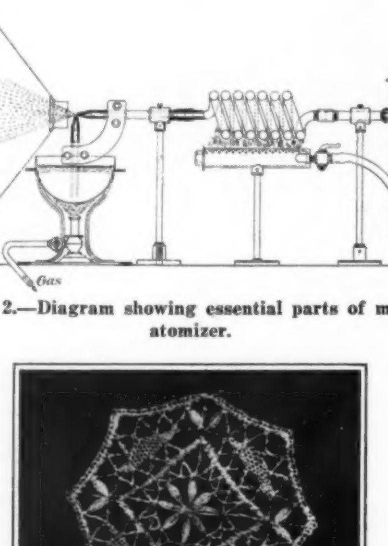


Fig. 4.—Metalized laces and fabric.

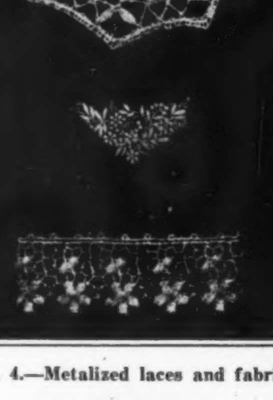


Fig. 5.—Metal-coated concrete molding.

the wire at just exactly the same rate as it is consumed, atomized and sprayed from the nozzle. This adjustment can be made very accurate, so that in this method of working there is practically no loss of material whatever, and moreover, metals of even the highest melting point such as gold and platinum can be used. In special cases, if the temperature of the oxy-hydrogen blowpipe should prove insufficient, resort may be had to the electric arc.

As the final result of evolution of the apparatus just described, there was finally produced a device, shown in Fig. 3, and no larger than an ordinary revolver, a device which moreover has been found most efficient in practice. It has done duty for eight hours at a stretch without giving any trouble.

In Fig. 3 the front wall is shown broken away, exposing the internal part of the device. Air under pressure passes through a thick tube, which also contains the channels for the oxygen and hydrogen admission, and actuates a turbine (at the right in the center) which rotates at very high velocity (up to 35,000 revolutions per minute). The motion is transmitted to a large disk on the left, and then to a smaller disk above. Between these two the wire passes, being firmly gripped by them and fed to the nozzle. The melting and atomization is effected just as described above.

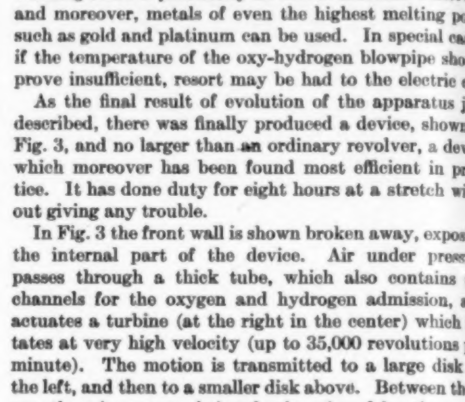


Fig. 3.—The metalizing pistol. The latest stage in the evolution of the Schoop process.

Passing on now to a consideration of the field of application of the new process, we have to distinguish two classes of cases. On the one hand it may be desired to produce a permanent coating to remain attached to the surface on which it is originally projected. Secondly, it may be desired to temporarily coat an object and to then detach the coating thus formed and use it as a mold or cast.

Applications of the first kind are so numerous that one hardly knows where to begin their enumeration.

All containers employed in the industry, in mines, in chemical works, in breweries, etc., are either provided with a resistant coat of paint, or are lined with lead, copper, tin or other metal. In all these cases the atomizing process commends itself highly in place of all the methods hitherto employed. And no small advantage lies in the fact that it is possible by means of the little spray pistol, to gain access to every nook and corner, even where a brush does not readily and thoroughly penetrate.

Moreover, the thickness of the layer can easily be regulated by continuing for a greater or less length of time. In this way layers from 112,500 of an inch to half an inch can be produced, which moreover are extremely uniform and dense. The density of the coating may be adjusted by suitably selecting the gas employed in the atomizer. Thus in the case of lead, when steam was used, a specific gravity of 9.5 was attained, while by using hydrogen a lead coating with a density of 11 to 11.3 was obtained. The possibility of producing a comparatively loose layer will be of particular interest in the production of accumulator lead plates, which should be as porous as possible.

As a rule it will be desirable to produce thin coatings of metals. A particular case of this kind is the manufacture of electrical cooking and heating apparatus, in which it is desirable to produce very thin metallic deposits of a conductor, to act as a "resistance," upon a suitable substratum, such as porcelain or earthenware. Hitherto it has been customary for this purpose to coat the substratum with a layer of the resinates of the noble metals, which are subsequently reduced. It is obvious here that the use of Schoop's method will be a great gain. Again, in copper-plating carbon electrodes and in making all sorts of electrical connections, the metal spray process should prove invaluable. The joining of two metal surfaces, for instance, at the edges of a tank, can be effected by the Schoop process more satisfactorily than in any

other manner. In fact a joint so produced is so intimate that it cannot be distinguished with the eye.

Again in coating iron surfaces to protect them against rust, especially in the case of structures presenting a complicated surface, the new process should prove invaluable, as it enables one to gain access to every nook and corner. A metal coating thus applied will give vastly better protection than the usual coat of paint, which has to be renewed at frequent intervals and corresponding expense.

As compared with electroplating the Schoop process possesses the great advantage that the somewhat delicate operation of "pickling" (cleaning) metal before coating becomes unnecessary. Every one conversant with the act of electroplating knows the difficulties which are apt to arise in this pickling operation. In applying Schoop's process a simple cleansing with wire brushes or by the sandblast suffices. But the most serious objection to electroplating is that the rate of deposition of the coating is strictly limited. In Schoop's process vastly greater speeds are readily attainable. Again aluminium, for example, cannot be coated at all by electroplating, while the Schoop process is applicable, of course, not only to all metals whatsoever, but also to the most varied and delicate materials, such as wood, paper, fabric and even lace.

An important application of metal-coated fabrics prepared by the Schoop process is their use for balloon envelopes, which can be rendered almost absolutely impermeable, without losing their flexibility. The fact that such fabric becomes a good conductor of electricity is an additional advantage, and it has been suggested to make clothing for workmen in electrical installations from metalized fabric, as this would afford them considerable protection against shock by contact with live wires or leads. Metal-coated fabric has also been found to furnish an excellent screen for optical lantern projection, a screen which possesses all the advantage of the aluminium screen, while being much cheaper, and at the same time handier, since it can be rolled up when not in use.

As regards the possible application of the process to coating wood, the field appears practically unlimited. Aside from the production of purely decorative effects, we need only point to such examples as the coating of railway ties, telegraph posts, fence posts, etc., for protection against the weather, against the moisture of the ground, or against insects. Again, the wooden hulls of ships can be copper-coated with greater ease and perfection by Schoop's process than by the usual method of applying the metal in sheets. In packing goods airtight for transport by land and sea the new process should prove invaluable. Bottles may be sealed, and in some cases (e. g., eggs) food materials themselves given a protective metal coating.

Some idea of the artistic effects attainable by the new process can be gained from the accompanying illustrations. Thus Fig. 4 shows two specimens of metalized lace, and a very fine example of silk "inlaid" by Schoop's process with a metal pattern.

The possibilities of metalized concrete are well brought out in Fig. 5, which shows an artistic design molded in concrete and coated with brass.

Finally there are those applications in which a detachable coating is produced upon a surface, in order to prepare a mold for casting a copy of the original. In this case the surface is first prepared by giving it a fine coat of graphite, talcum, or fat, from which the metal coat afterward detaches itself readily.

Not only is this method of making casts applicable to all ordinary purposes, but dentists, for example, can by its aid prepare artificial palates by spraying a metal coating over the mold made in the usual manner from a plastic mass. A similar process can be employed for the preparation of artificial limbs. The variety of possible applications is in fact unlimited. Thus the well-known method of identifying criminals by their finger prints can be improved upon by making metal casts of the imprints by Schoop's process. Grammophon plates can also be copied with complete success by this method. This is probably as severe a test as could well be applied as regards the accuracy of the copy. Another important application is in the reproduction of half-tone blocks, which has hitherto been effected electrolytically. Not only is it possible to use any desired metal, such as iron for example, but as many as thirty copies have been prepared in the almost incredible short space of one hour.

And all the possibilities of the new process are far from being exhausted. The inventor is still working on its further development. Among these is its application to spraying glazings and enamels; the production of alloyed coatings by spraying on two or more metals from separate nozzles or from one nozzle (which may for instance be fed with a wire of several strands twisted together).

The Laws of Similitude*

And Their Application in Aeroplane Design

By L. Bairstow, A.R.C.Sc.

The title of this paper does not immediately suggest aeronautics, but the connection is very intimate, as the laws of similitude constitute the theory of the use of models. Aeronautics, or rather aerodynamics, is almost entirely an experimental science at present, and a glance backward through time will show how many of the fundamental data of the subject are derived from experiments on models. We have, in the first place, Langley's researches, which showed that sufficient lift could be obtained to make models fly with such light engines as he was able to construct. The development of the gasoline motor removed the greater part of the engine difficulty, and with that out of the way, Langley's figures for model planes, modified by Lilienthal's experiments on cambered models, provided the initial information from which the earliest flying-machines were constructed.

It is true that the balancing of aeroplanes as introduced by the Wright brothers was a revolutionary achievement, carried out in the first instance on a full-scale glider, but the later considerations of inherent stability were first enunciated by Mr. Lanchester from experiments on models, while the data underlying Prof. Bryan's mathematical investigations of stability are obtained solely from experiments on models.

All constructors of aeroplanes are familiar with the model researches of Eiffel, and use his results in their drawing-office practice. They are also aware that full-scale experiments are very difficult to carry out. At the present time the recorded full-scale measurements are extremely few in number, and are confined entirely to determinations of thrust and gliding angle. They are not nearly advanced enough to be used for a determination of the best form of aerofoil or strut. This being the position, it is evident that we must still continue to make experiments with models, and in doing so must ask ourselves whether the flow round models is like that round the flying-machines; and if not, we must know how to find our conversion factors. A true theory of aerodynamics would answer those questions for us completely, but, unfortunately for us, the answers to such questions are beyond the reach of our present mathematical knowledge.

Fig. 1 illustrates a motion which has defied the mathematician. The object in the center is an aerofoil looked at from one end, and the streaks are the tracks of brightly illuminated oil-drops. The exposure was one second, and during that time each drop had been moving. The length of the trail shows the average velocity. Here the fluid is still, while there it is moving very rapidly. Over the back the pressure of eddies is clearly shown. A satisfactory theory of hydrodynamics would be able to predict all this for us; as we have not got such a theory, the results have to be obtained experimentally by some such method as that by which the slide was produced.

Although we cannot predict the motion in any given case, we can have a theory which tells us how to get the same results from two models, and that even when we cannot see the motion. This is the principle of similitude. The laws are not always simple, and there are an infinite number of them, only one of which is applicable to a given experiment. I hope to be able to show how we decide which law will be appropriate to the various motions with which aeronautics is concerned.

In the allied subject of ship propulsion, as we all know, the testing of models of ships has been carried on for years, and the law of similitude is there embodied in the statement that models should be tested at a speed which is related to the speed of the ship in proportion to the square root of the length of the ship expressed as a multiple of the length of the model. This law is known as Froude's law of corresponding speeds. On investigation it is found that this condition is necessary in order to make the waves of the same shape to scale for both the model and the ship. As there are no surface waves in air, it will not be surprising that the same law is not applicable to experiments on the lift and drift of planes. On the other hand, it is applicable to some of the problems incidental to the study of the stability of aeroplanes, but obviously not because of the production of surface waves.

The theory involved in the laws of similitude is strictly accurate, and is just as true as Newton's laws of motion. It is, in fact, an exceedingly direct application of those laws to experiment.

* Lecture delivered before the Aeronautical Society of Great Britain on February 22nd and published in *Engineering*.

Fig. 1.—Flow of fluid round an aerofoil.

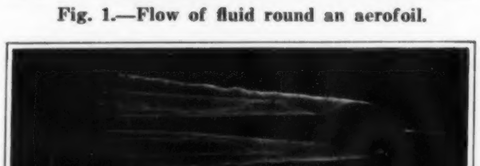


Fig. 2.—Flow round an inclined square plate; low velocity (water).

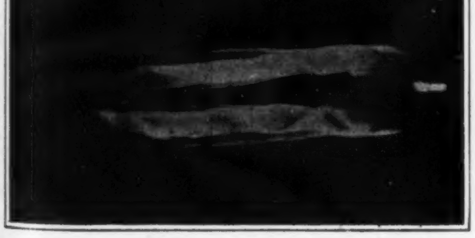


Fig. 3.—Flow round an inclined square plate; low velocity (air).

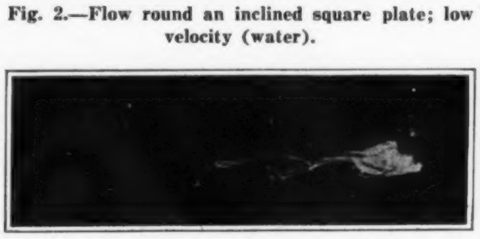


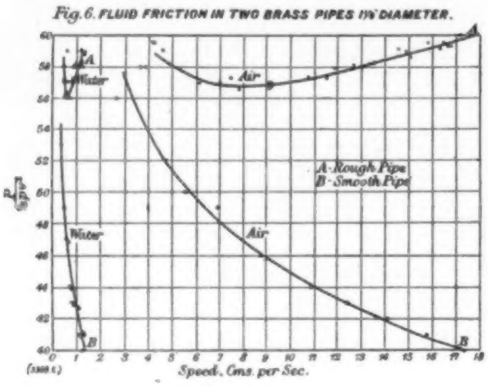
Fig. 4.—Flow round same plate as in Fig. 2; high velocity (water).

Fig. 5.—Flow round same plate as in Fig. 3; high velocity (air).

The data to which the theory applies are experimental, and the accuracy of the results is therefore dependent on the truth of the experimental conclusions.

A simple illustration will show the whole process of reasoning involved from the beginning of an experiment to the development of the law of similitude corresponding to it. Suppose, for instance, that we have been making experiments on a simple pendulum, and that as a result we have found that any alteration in the length produces a very appreciable influence on the time of oscillation; we have also found that the forces producing the oscillation are due to the attraction of the earth on the pendulum-bob. If the experiment is made in air, there are also small effects due to air resistance; but when the experiment is carried out in a vacuum, as it often is, nothing else appears to affect the motion.

Fig. 6. FLUID FRICTION IN TWO BRASS PIPES 1½" DIAMETER.



The experimental evidence is now complete, and the following theoretical problem can be investigated:

"The time of swing of a simple pendulum depends on its length l, on the value of g at the place, and on nothing else. Find the law connecting the time of oscillation with the length and attraction." The complete solution to the problem by means of a differential equation is well known to all engineers in the form

$$T = 2\pi\sqrt{l/g}.$$

Except that we cannot say that the constant outside the root sign is 2π, we can obtain this answer without reference to differential equations. To develop this method we turn to Newton's laws of motion, and from them we discover that all measurements connected with motion can be expressed in terms of the units of mass, length and time, this being usually referred to as the theory of dimensions. In the above equation we have

$$T = \sqrt{L/L/T^2} = T,$$

and the dimensions on both sides of the equation agree. In fact, any failure to obtain agreement is a certain sign of error in the calculation. The important point to notice is that it is impossible to find any other combination of the two quantities l and g which will have the dimensions of T. Hence, we can say that because the dimensions agree we must have

$$T = \text{constant} \times \sqrt{l/g}.$$

The process for finding the laws of similitude is simply that of finding the only arrangement of all the quantities which matter, so that the dimensions on both sides of an equation agree. If we apply the method to dirigibles, and ask ourselves, "If several dirigibles are made to the same drawings, but to different scales, which is most likely to break, the smallest or the largest?" Then, since the design is fixed, the stress depends only on the size l and on the weight of the materials of which it is made w pounds per cubic foot, and we write:

$$\text{Stress} = f\,(w\,l).$$

It is required to combine l and w so that the answer has the dimensions of stress. The only possible answer is:

$$\text{Stress} = \text{constant} \times w\,l.$$

If the materials are the same from one size to another, w is constant, and we see that the bigger the dirigible the bigger the stress, and that doubling the size of an air-ship without altering the drawings or material reduces its factor of safety to half.

The application to similar aeroplanes which are to travel at the same speed is equally easy, and we find that increase of size does not produce difficulties due to increased stresses.

These rules are not new; engineers have acted on similar rules for a long time. Railway bridges of short span, in which the stresses are mainly due to the train, follow the aeroplane law. Long-span bridges, like the Forth Bridge, in which the stresses are mainly due to the weight of the bridge-girders, and only in a minor degree to the train, follow the dirigible law, and it is recognized that there is an upper limit to the size of cantilever bridges, just as there must be an upper limit to the size of dirigibles.

Interesting as these applications are, they are not so important as the application of the principles of similitude to the motion of fluids, because we have more complete theories available. Theories of hydrodynamics and aerodynamics are, however, very incomplete, and in naval architecture are rejected in favor of experiments on models. The particular problem is here: Find the resistance due to waves. Obviously the waves depend on the earth's attraction, on the length of the model, its velocity, and the density of the fluid, and, so far as is known, on nothing else to any appreciable extent. The most general expression for resistance which contains all these quantities, and has the right dimensions, is

$$\text{Resistance} = p\,v^2 l^2 f\left(\frac{v^2}{l\,g}\right).$$

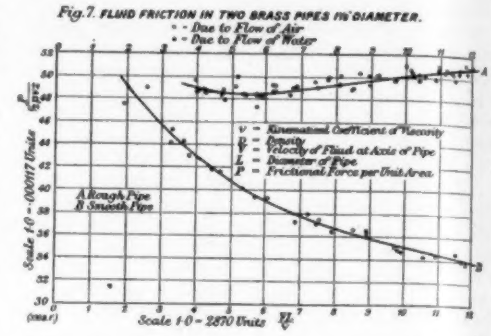
Now f is a general unknown function, and at first sight it might appear to be impossible to make any use of the equation. A little analysis, however, shows how to avoid the difficulty if only we are in a position to test a model of the ship. On the model earth g is constant, and if we make v^2/l have the same value for the model and ship, then $f\left(\frac{v^2}{l\,g}\right)$ has the same value; this is just the statement of Froude's law of corresponding speeds. Now go further; we have used g as being the earth value for both model and ship. Suppose that the ship was for use on Mars, and the model test was to be made on the earth, then the equation tells us that since the attraction on Mars is less than that on the earth the model must be towed faster in a given proportion. The reason for this extension of Froude's law is easy to see; since the earth attracts the water more strongly than does Mars, it requires a greater disturbing force, and therefore greater speed on the earth to create waves as big as those on Mars at the lower speed. It has been known for a long time that frictional resistances do not follow Froude's law, and these forces are calculated separately. Suppose, however, that we are deeply submerged, then the surface does not matter, and we are left entirely with friction. That is the law in this case. Experimental evidence now says the resistance depends on the speed, the length of the model, the velocity, and on the density and viscosity of the fluid. As before, we find

$$\text{Resistance} = p\,v^2 l^2 f\left(\frac{v\,l}{V}\right)$$

is the only possible relationship between the above quantities which has the correct dimensions. V is the mathematical coefficient of viscosity. The models will now produce similar disturbances in the fluid if $\frac{v\,l}{V}$ is constant. This might be called the law of corresponding speeds for fluid friction, and was first stated by Osborne Reynolds. It differs from Froude's law of corresponding speeds in one particularly important respect. If we take two models of different sizes, the friction law says that the velocity past the bigger of the two must be the smaller, while Froude's law says exactly the opposite. Turning now to an experiment in which the earth's attraction, and therefore presumably Froude's law, does not come in, we can see (Fig. 2) in a striking way how the mathematical conclusions are borne out in fact. The motion of the water at the back of the square plate, inclined to a current of water, is rendered visible by coating it with Nestle's milk, and the photograph shows a continuous corkscrew sheath in the wake of the plate. Imagine the speed to be gradually raised.

For some time nothing remarkable happens, but eventually the flow changes its character to that represented in Fig. 4. Instead of a continuous spiral streak, the eddies now come off in definite loops, and there is no resemblance between the new and the old flows. Now, further, imagine the small plate removed and one twice its size substituted, and the experiment again repeated to find the velocity at which the flow changes. This has been done at the National Physics Laboratory, and it is shown that as nearly as it can be measured the change occurs in accordance with the friction law, i. e., doubling the size of the plate and halving the velocity always produces the same type of flow. This observation definitely proves that these eddies are produced by friction, and do not obey Froude's law, as they are often supposed to do. Now carry the experiment further and change the fluid from water to air. A channel was made to take a model twice as big as that in the water channel, and the flow was made visible by smoke. Exactly the same changes were observed (Figs. 3 and 5), but the speed at which the flow changed was very much higher in the air than in the water. The mathematics says between six and seven times. We have not yet been able to do the experiment so accurately as to get a better number than that deduced from the laws of similitude.

Fig. 7. FLUID FRICTION IN TWO BRASS PIPES 1½" DIAMETER.



I will conclude by referring to the two other experimental illustrations of the friction law of corresponding speeds. One refers to skin friction, and has a bearing on the calculation of the resistance of dirigibles and aeroplane bodies, and the other refers to the resistance of stay wires. In each case the same results have been plotted in two ways, one of which compares the observations at the same speed, and the other at corresponding speeds. The simplicity of the latter is strikingly illustrated by the difference in the curves. For the pipes we see that the curves have no apparent connection when plotted at the same speed for air and water flowing through the same pipe. At corresponding speeds they could not be separated without the help of distinguishing points (Figs. 6 and 7).

For wires the lines at the same speed basis have different inclinations, and do not always pass through the origin (Fig. 8). On a corresponding speed basis, however, all the observations fall on a single curve without exception (Fig. 9). In either case we could use the corresponding speed curves for all sorts of diameters, all sorts of speeds, and all sorts of fluids. The question which we set ourselves to answer at the beginning of this paper is solved when we know any one of these curves from the model to the full-scale machine. To do this is a somewhat difficult task in some cases, and all accurate full-scale experiments will be useful in order to establish model testing in a firm and unshakable position; until then it appears to be impossible to do anything better than the predictions made from models, using a discretion derived from experience on actual flying-machines.

Fig. 8. RESISTANCE OF SMOOTH WIRES.

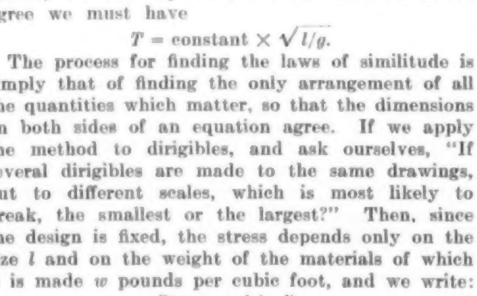
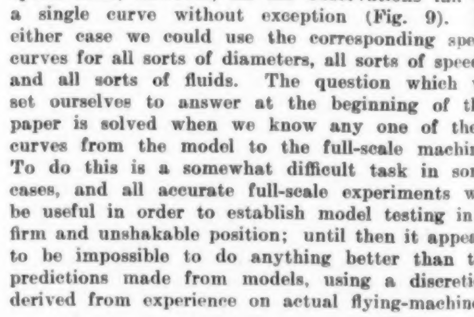


Fig. 9. RESISTANCE OF SMOOTH WIRES.



The Subliminal Self*

Unfathomed Depths of the Human Mind

By J. Arthur Hill

I.

There has probably always been a suspicion, among thinkers, that we are greater than we seem to be. For one thing, the idea flatters our natural vanity, or, to put it more mercifully, our hopes and longings and aspirations, and is a hospitable refuge, giving ampler air and spaciousness in times of suffering, due to our limitations. It is expressed in many forms and places. In the Bible, mortals are referred to as "gods" (Psalm lxxxii, John x); in Christian theology the Divine and human natures are united, not in one unique instance, but in all (e. g., Dante, near the end of the "Paradise" and elsewhere); in Plato's "Republic" the human soul descends from supernal realms, drinks of Lethe, and forgets its previous experience (limits itself, puts off its greatness, takes on the form of a servant); and this *kenosis* is closely paralleled in some of the teachings of Hinduism. The standard modern expression of the idea is that of Wordsworth in the "Ode:"

"Our birth is but a sleep and a forgetting!
The Soul that rises with us, our life's Star,
Hath had elsewhere its setting,
And cometh from afar:
Not in entire forgetfulness
And not in utter nakedness,
But trailing clouds of glory do we come
From God, who is our home."

And elsewhere, in a sonnet, he finishes with the often-quoted line: "We feel that we are greater than we know."

Until recently these ideas were left to the domain of the speculative philosopher, or poet, or prophet. But within the last quarter of a century or so they have more and more claimed the attention of the scientific man, and they have more and more obtained the support of actual, scientifically observed facts.

II.

If there is something mental or psychical in us beyond the bounds of our own minds or souls as we know them in self-consciousness, how are we to discover this something; how become aware of it? The answer cites various classes of fact, and the inferences to be drawn from them.

(1) *Subliminal Sensation.*—One small fly walking over the back of my hand arouses no sensation. It is not felt. But if there were six flies instead of one I should feel them. Thus, six times nothing produces something; or, to put it the other way, a given amount of sensation is produced by a certain stimulus, but when the latter is decreased by five sixths the remaining sensation is not one sixth of the original sensation, but, on the contrary, is *nil*. In other words, there is a "threshold;" below this threshold of intensity a stimulus produces no conscious sensation; but we suppose that it produces a subconscious or subliminal one. Something in us perceives the one fly, even if the normal mind does not. This is borne out by various experiments in hypnosis, whereby the subliminal can be put, as Prof. James used to say, "on tap." Consciousness is like a spectrum-band. There are sensations which we do not normally become aware of, as there are rays of light which we cannot see.

(2) *Subliminal Intellection.*—For this the evidence is ample. There is no doubt whatever that something in us thinks, reasons and calculates without the normal consciousness knowing anything about it. The most striking experiments on this point are those of Dr. J. Milne Bramwell, who ordered hypnotized patients to carry out some action after their arousal from the trance, as, for example, to make a cross on a piece of paper at the end of a specified period of time, reckoning from the moment of waking. In the normal, waking state, the patient knew nothing of the order; but a subliminal mental stratum knew, and watched the time, making the patient carry out the order when it fell due. The period varied from a few minutes to several months. For instance, Dr. Bramwell would say to the hypnotized patient: "You will feel impelled to make a cross on a piece of paper, and will do so, putting down the time also. This is to take place at the expiration of 24 hours and 2,880 minutes." This is one of the actual cases; the order was given at 3:45 P. M. on Saturday, December 18th, and it was carried out correctly at 3:45 P. M., December 21st. In other experiments the periods given were 4,417, 8,650, 8,680, 8,700, 11,470, 10,070 minutes. All were carried out correctly. In the waking state the patient was quite incapable, as most of us would be, of calculating mentally when these times would elapse. But the hypnotic stratum could do it, and could insure that the order should be carried out at the exact moment of falling due. In one instance the time happened to expire during the night. The patient made the cross on paper at her bedside at the correct time, apparently without waking, for she had no recollection of having done it.[1]

We may say, then, that not only is there some subliminal part of our minds that can calculate, but also that this something can calculate better than the ordinary waking consciousness.

The same conclusion is arrived at by consideration of the performances of "arithmetical prodigies." It is often found that these curiously endowed people can solve in a few seconds, and sometimes almost instantaneously, problems which would utterly baffle most ordinarily educated people, and which would take an average arithmetician a quarter of an hour's rapid work with pencil and paper. Yet these prodigies, who, by the way, are often, like Dase, Buxton and Mondeux, of very low mental power so far as their normal faculties are concerned, are entirely unable to tell how they do it. They do not consciously work the sum out. They let it sink into their minds and then wait for the answer to be shot up. It is like putting the plum-pudding into the geyser to be boiled; or like putting the pig into the Chicago machine. It goes in pig and comes out sausages. The intermediate processes are hidden from us. The calculation is made subliminally, below the threshold of ordinary consciousness.

Subliminal Memory.—The results of hypnotic experiment and of the study of pathological cases of split personality (such as Dr. Morton Prince's Miss Beauchamp) are sufficient to prove beyond question that the subliminal memory is wider than the normal one. Many things which we "forget" seem to slip down below the threshold, thus becoming lost to ordinary consciousness, but remaining accessible by hypnotic methods. Or it sometimes happens that they are recovered in sleep, when the conscious self is in abeyance, and the other strata of the mind come to the top. Or they turn up in automatic writing with planchette or a pencil. In a recent striking case, reported to the Society for Psychical Research, an automatic writer had communications from a "spirit," who called herself Blanche Poynings, and gave a great deal of historical detail which the automatist did not consciously know. But it was afterward found that Blanche Poynings was a character in a novel which the automatist had had read to her many years before, and the novel contained all the historical details given. All this had been "forgotten." It had slipped down below the threshold. But the subliminal strata still retained it and could produce it (in the usual mystifying spirit style) when tapped by a borehole, sunk, so to speak, through the upper level of consciousness, by means of automatic writing.

Subliminal Emotion.—This is a reality also, though perhaps less provable. An interesting example of the necessary evidence occurred in Mrs. Verrall's experience with automatic writing some time ago. [Mrs. Verrall is a classical lecturer at Cambridge; translator of "Pausanias;" widow of Dr. A. W. Verrall, late King Edward Seventh Professor of English Literature.] This automatist, without experiencing conscious emotion, found the tears running down her face when she roused herself from a semi-conscious state in which she had been writing automatically. The script, on examination, turned out to contain references to two friends who had died under tragic circumstances; but Mrs. Verrall was quite unaware of the contents of the script until she had read it. Evidently some part of the mind was not only thinking and remembering and making the fingers write without conscious direction, but was also feeling and suffering, and making the eyes overflow without the conscious mind knowing why. (*Prodceeings S.P.R.*, XX., p. 15.)

Subliminal Creation.—This is the best proved of all, for most of us prove it for ourselves every night. In dreams every one of us becomes novelist or dramatist, inventing situations, usually absurd to the waking mind, which are absolutely novel in our experience. And, to step at once to the higher plane, it can be said, without fear of contradiction, that all works of genius, all creations, are uprushes from subliminal depths. They are not produced by taking thought. The process is felt to be quite different from that of the faculty which thinks and reasons consciously. It is more a waiting than a working. "All is as if *given*," said Goethe. (*Alles ist als wie geschenkt.*) The inspiration comes from below the threshold. Many great writers amply bear out Goethe's dictum. Ibsen wrote "Brand" in three weeks in a state of feverish exaltation, scrambling out of bed to write down, half asleep, the lines which rose tumultuously to the surface of his mind. Charlotte Brontë could write freely on some days, while at other times the story hung fire for weeks at a time, refusing to unroll itself; then a volcanic burst, and she would write furiously until she was ill with the strain. In her preface to Emily's "Wuthering Heights," discussing the rightness of creating such characters as Heathcliff, she states the case in unsurpassed language:

"But this I know; the writer who possesses the creative gift owns something of which he is not always master, something that, at times, strangely wills and works for itself. He may lay down rules and devise principles, and to rules and principles it will perhaps for years lie in subjection; and then, haply without any warning of revolt, there comes a time when it will no longer consent to 'harrow the valleys, or be bound with a band in the furrow,' when it 'laughs at the multitude of the city, and regards not the crying of the driver,' when, refusing absolutely to make ropes out of sea-sand any longer, it sets to work on statue-hewing, and you have a Pluto or a Jove, a Tisiphone or a Psyche, a Mermaid or a Madonna, as Fate or Inspiration direct. Be the work grim or glorious, dread or divine, you have little choice left but quiescent adoption. As for you, the nominal artist, your share in it has been to work passively under dictates you neither delivered nor could question, that would not be uttered at your prayer, nor suppressed nor changed at your caprice. If the result be attractive, the World will praise you, who little deserve praise; if it be repulsive, the same World will blame you, who almost as little deserve blame."

This would be indorsed by Scott, who dictated "The Bride of Lammermoor" while ill and in an abnormal mental state, and found a great part of the story quite new to him when he read it in the book. Also by Stevenson, who tells us that he wrote fifteen chapters of "Treasure Island" in fifteen days, then stuck completely; "my mouth was empty; there was not one word of 'Treasure Island' in my bosom;" but again the tide rose, "and behold! it flowed from me like small talk," and he finished it at the rate of a chapter a day. It is interesting to remember, in this connection, that Stevenson used to *dream* most of his plots, as he describes in "Across the Plains."

Similar statements of experience could be culled from other fields of creative art. Perhaps it is even more marked in music than in literature. Mozart, for example, had a vivid perception of the extraneous nature of the afflatus, extraneous, that is, to the conscouis mind; and, among painters, Watteau frankly and quaintly avows himself puzzled at the "queer trick he possesses," evidently not knowing in the least how he did it. Indeed, no genius *does* know "how he does it." If he knew, he could teach others to do it also. No, it is not the knowing part of the mind that is the agent, nor is it any part that the consciousness can understand. The power lies deep buried in the subliminal levels. It is only its results, its exfoliations, that we see.

It is established, then, that there can be mental or psychic activity of many kinds, sensational, intellectual, reminiscent, emotional, creative, over and

* Reproduced from *Knowledge*.

[1] *Proceedings*, Society for Physical Research, xii., p. 185.

above anything that the conscious mind is aware of. Science has proved that we are greater than we knew. The hinter horizons of the mind have receded and fled away. New vistas open out in metaphysical psychology. The soul is become immense, immeasurable. We are suddenly transplanted from a cellar dwelling to the illimitable prairie. Not only do we not know what we shall be, but we do not even know what we are. Like Malvolio, therefore, we may again "think nobly of the soul." The Psalmist, quoted approvingly by Jesus, said: "Ye are gods." A blinding and stunning thought! But, whether we go so far as that or not, and, after all, it is not a very great thing to say, for we are certainly more wonderful creatures than many of the Greek and Norse gods, we can at least subscribe to that profoundly wise and suggestive triplet of Emerson's, who in so many of these things had a curiously prophetic instinct:

"Draw, if thou canst, the mystic line,
Severing rightly his from thine,
Which is human, which divine."

III.

The late Prof. William James used to say that he thought the most fundamental problem in philosophy was that of the One and the Many. How can a Universe which is Whole and One, containing everything that is, both material and immaterial, how can this One Thing be at the same time Many? And if we start with the manyness, this and that tree and house and mountain and country, this and that microbe, blade of grass, butterfly, how are we ever going to visualize them as one, when they are so incontestably disparate? The problem is at present insoluble. We can begin at either end, but there is no meeting-place in the middle. One remains One, and Many remains Many.

But in the region of mind or soul the modern doctrine of the subliminal self, which, first propounded by Myers twenty-five years ago, was afterward hailed by James as the greatest modern advance in psychology, and which is continually being buttressed by new facts, is at least pointing to a kind of solution to this problem. Human minds are many, it is true; but they are closely alike, and in all biological science it is found that close similarity points to a common source. In some sort, then, it is to be surmised that all human minds descend from a common source. But the phenomena of psychical research, telepathy, to name only one, indicate that there is absolute *connection* between the minds here and now existing, in ways over and beyond those accounted for by the known senses. And there is reason to believe, though the evidence is too complex to specify here, that in telepathy and allied phenomena it is the subliminal part of the mind that is active. These and other considerations point to the supposition that though our ordinary normal consciousnesses are severed from each other, and apparently distinct, so that we have to communicate with each other by the clumsy means of speech and writing, we are nevertheless all in connection with each other in the subliminal levels. To vary the metaphor, each of us is like a stream of water issuing from one of the thousands of taps in a city, but the water is the same, coming from the same reservoir. The same soul thinks in all of us. The One *is* the Many.

It may be said that this conclusion is a speculative and abstract proposition. On the contrary, it is extremely practical; for it has close connection with human action. Remember how we feel about our brothers and sisters; how we stand shoulder to shoulder with them, feeling that the interest of the family is a common interest, for which each individual is bound to fight. Remember also how, broadly speaking, the individual's welfare is bound up with that of the family, and what is good for it, is also good for its component units. And now think what would happen if all men, or even all civilized and educated men, could regard humanity at large as one huge family, one in interest and, further, one in reality and essence, being joined together in that subliminal region, the individual separation of the conscious minds being illusion, due to ignorance of our real nature. Would not a revolution be effected? I am sure it would. And, sooner or later, it will. The religious doctrine of the brotherhood of man was a noble moral inspiration but its appeal was to the affective side, and it was consequently inoperative against the coldly intellectual. But it is now supported by science. Knowledge now goes hand in hand with faith and love. A new dawn begins to send up its shafts of light in the East. A new era is at hand.

According to present conventions, it is bad form to be in earnest about anything; the proper thing is to cultivate a manner of light banter which shall give an impression of cleverness and wit. The popularity of the fashion is very comprehensible; for there are always plenty of people who wish to seem clever but are not. And the trick of it is easily acquired. Be cynical and flippant about everything, and you will get the credit of having seen through the illusions of the world, and of being a deeply wise man who conceals his wisdom. But it is a pose and an affectation. There is really no disgrace about being serious, at least occasionally, nor in being honest, even almost habitually! If I seem too solemn or too enthusiastic in my vision of the future when the unity of mankind shall be more fully realized, I appeal from the decadent trifler of to-day to the vogorous thinker of to-morrow, from Philip drunk with sophistication and selfishness to Philip sober with clear eyes and better ideals. Better times are coming. We are beginning to see that we are not a "concourse of warring atoms," but a vast multitude of units which fit together and make up an organism; and that what is good or bad for the organism is good or bad for the units. Solidarity and homogeneousness are the watchwords. Individualism has been over-accentuated. We must see humanity steadily, and see it whole, a whole, however, within a still larger Whole of the entire Cosmos.

Infusorial Earth Has Many Uses

The amount of infusorial or diatomaceous earth and tripoli produced in the United States in 1912, according to the United States Geological Survey, was valued at \$125,446—\$22,016 less than that of 1911.

Infusorial earth has been used largely as an abrasive in the form of polishing powders, scouring soaps, etc., and lately it has been found useful in the manufacture of dynamite as an absorber of nitroglycerine. It is also used as a packing material for safes, steam pipes, boilers, and as a fireproof material. In this country a new use for the material is reported in the manufacture of records for talking machines. In Europe, especially in Germany, infusorial earth has lately found extended application. It has been used in preparing artificial fertilizers, especially in the absorption of liquid manure, and in the manufacture of water glass, cements, glazing of tiles, artificial stone, paper, sealing wax, fireworks, guttapercha objects, Swedish matches, etc.

Infusorial or diatomaceous earth is made up largely of silica, is a variety of opal, and represents the remains of certain aquatic forms of plant life known as diatoms.

Tripoli is a light, porous siliceous rock, supposed to have resulted from the leaching of calcareous material from the siliceous limestones, and is used as an abrasive, in the manufacture of filters, and in the paint industry as a wood filler, for enameling, etc.

Chemical Effects of Radium Rays

It is not a little remarkable that, while it was claimed, in days when not more than a few milligrammes of radium were available, that radium radiations could produce the most far-going chemical reactions and changes, the recent researches conducted at the Institut für Radiumforschung, in Vienna, where radium in its way plentiful, shows that radium has, indeed, certain effects on organic and inorganic compounds, but that these effects are, on the whole, feeble, and in most instances far weaker than those of ultra-violet light. Reports on these researches have been presented to the Vienna Academy of Sciences by A. Kailan, by E. von Knaffl-Lenz, and W. Wiechowski, and by others. The latter contradict the statement made by Gudzent in 1910, that solutions of sodium urate were decomposed by radium emanation, breaking down finally into ammonia and carbon dioxide. Gudzent did not say how much radium he had at his disposal, but it must have been very little; the investigators mentioned tried 86 milligrammes of radium salt for many days under different conditions and observed no decomposition at all. Kailan first investigated the decomposition of hydrogen peroxide by the emanation and the various rays from 160 milligrammes of radium salt, which is, of course, a large amount. Hydrogen peroxide is easily decomposed by many agents, as well as by light, and there was an increase in the rate of decomposition under exposure to radium rays; but heat, represented by a difference of temperature of a few degrees, proved a much more powerful agent than the radium. Both radium and light radiations, on the other hand, also produced hydrogen peroxide as well as ozone, and the possible formation of these two compounds complicates all such experiments very much. In acid solutions Kailan observed a slight decomposition by β and γ rays of potassium bromide, while potassium chloride was not attacked. The same rays turned orthonitrobenzaldehyde into an acid; but a quartz-mercury lamp was 20,000 times more powerful in that reaction. Quinone, which is easily decomposed by blue-violet light, was not attacked at all. Normal oxalic acid remained unchanged after 1,000 hours' exposure. The inversion of sugar was accelerated by the radiations; but, oddly enough, those sugar solutions which had not been sterilized, suffered more from fungus growth than in the absence of the β and γ rays. We do not consider these investigations as in any way conclusive.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, AUGUST 16, 1913

Published weekly by
Munn & Company, Incorporated, Charles Allen Munn, President
Frederick Converse Beach, Secretary and Treasurer;
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	\$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents

16, 1913

ence of
ch more
radium
lso pro-
ne, and
mpounds
ch. In
omposi-
e, while
he same
n acid;
es more
is easily
attacked
changed
sion of
t, oddly
ot been
th than
do not
ay con-

are in a
y branch
composed
ts, thor-
atent ap-
e of the
echnical,

rld, who
mark ap-
e United

ys,
dway,
rk, N. Y.

CAN

1913

President
rer;

ass Matter

year $5.00
3.00
3.00
countries
tion
or check
w York

publish
distin-
nt arti-
ons, and
thought
orld.